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A REPORT ON INVESTIGATIONAL ACTIVITIES
AND FINDING OF THE COOPERATIVE FISHERY INVESTIGATION
AND TROUT MANAGEMENT PROJECT OF THE NORRIS DAM TAILWATERS

Prepared for

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Norris, Tennessee

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ACKNOWLEDGMENT

This report was prepared from the progress report of the Clinch River (Norris tailwater) fishery investigation as submitted by Hallett D. Boles of the USFWS and from the minutes of the annual Cooperative Trout Management Planning Session held annually between Tennessee Game and Fish Commission, TVA, and the U. S. Fish and Wildlife Service.

INTRODUCTION

Prior to the initiation of the Norris tailwater fishery investigation, most cold water fisheries research on reservoirs and reservoir tailwaters were being done in Middle Tennessee. These investigations were being carried out as a cooperative effort between the U. S. Fish and Wildlife Service and the Tennessee Game and Fish Commission with particular emphasis on Dale Hollow Reservoir and its tailwaters. After stocking schedules on Dale Hollow were completed in the fall of 1970, work in middle Tennessee was to be gradually decreased and the two cooperating agencies had proposed to divert activities to another study area in east Tennessee.

The Fisheries Division of TVA had requested a meeting between themselves and the Tennessee Game and Fish Commission to discuss a fish management plan for Norris Reservoir and its tailwaters. As a result of the request, it was concluded by the U. S. Fish and Wildlife Service and the Tennessee Game and Fish Commission that the most meaningful work with an east Tennessee trout investigation project would be a cooperative study between the three agencies. This cooperative effort would be inaugurated to investigate and develop the best possible management plan for a cold water fishery of the Norris tailwater area.

The first cooperative effort was begun with a meeting in the fall of 1970 between the three agencies. Little work had been done with the Norris tailwater area prior to this meeting. The most concentrated effort had been a trout stocking program carried out by the Tennessee Wildlife Resources Agency from 1962 to 1970. Stocking efforts by the agency had consisted of releasing three-to four-inch rainbow trout fingerlings from 1962 to 1970, six- to seven-inch trout from 1967 to 1969, and catchable size trout in 1964, 1966, 1967, and 1970 (Table 1). In conjunction with the stocking program carried out by the Commission, angler counts had been made daily from 1962 to 1970 by TVA personnel stationed at the dam from the dam to one-fourth mile downstream.

During the initial meeting in 1970, it was agreed by the cooperating agencies that little was known of the results of previous stocking efforts, existing habitat below the dam, and any detrimental parameters that may exist which would inhibit specific management plans. As a result, it was decided that initial efforts would be directed toward concentrating previous information for evaluation, beginning fact-finding surveys, and doing some experimental trout stocking for later evaluation.

The purpose of the Clinch River (Norris tailwater) fishery study is to investigate the potential for developing a desirable cold water trout fishery in the first 14 miles of the Norris Reservoir tailwaters (Figure 1). The investigation will concentrate its efforts toward evaluating three parameters which should affect the success of a cold water fishery in the Norris tailwaters: (1) the identification of the problems or factors which limit the success of the fishery, (2) modification of the controllable factor(s) which affect the fishery, and (3) the determination of the best management method for producing a desirable trout fishery.

PROJECT INVESTIGATIONAL ACTIVITIES AND RESULTS FROM 1971 TO 1973

Phase I 1971

Investigational activities in 1971 included trout stocking, fish population sampling, bottom fauna and food habit sampling, water quality evaluation, and a partial creel census.

Stocking

Two groups of trout were stocked in 1971 (Table 2). The first group was 3.77-inch fork-length fingerlings which were evenly dispersed by boat from the dam to 14 miles below during March. These trout were evenly distributed in order to assess the foraging potential at different locations of the 14 mile stretch of river by comparing the growth and condition of fish recovered from different areas. The second group consisted of 9.44-inch fork length trout which were released at a central point 10 miles below the dam in July. These catchable size trout were stocked at one location in order to determine if fishermen could be attracted to an inaccessible area and to detect any movement of these fish to different areas.

Fish Population Sampling 1971 (Table 3)

The fish population was sampled six times during 1971. The first sample was taken on February 21 at river mile 71.8 using rotenone and cyanide. A total of 170 fish were collected of which 61.2 percent were gizzard shad by number. Ten unmarked trout were taken but it was impossible to tell if these trout were residuals from prior stockings made by the state or wild trout. A second sample was attempted on the same date below river mile 77.0 but was unsuccessful using electrofishing gear.

On February 24, a third sample was taken with experimental gill nets at five areas: river miles 79.5, 76.7, 74.7, 72.8, and 70.2. No fish were taken at mile 70.2 due to water velocity and moss. A total of 34 fish were taken at the other four stations. These included gizzard shad, suckers, carp, bluegill, stoneroller, quillback, smallmouth buffalo, redhorse, and sauger.

On July 11, the routine stations at mile 70.2 and mile 76.7 were sampled using rotenone. At the mile 76.7 station, a total of 1,011 fish were recovered of which 90.5 percent were trout and 9.5 percent were rough fish. All but nine of the trout were from the 3.77-inch fingerling group stocked in March. Rough fish included hogsucker, threadfin shad, sculpins, quillback, gizzard shad, and stoneroller. At the lower station (mile 70.2) 162 fish were collected of which 77.8 percent were trout from the 3.77-inch fingerling group and 22.8 percent were rough fish consisting of logperch, gizzard shad, sculpins, golden redhorse, and carp.

On October 4, samples were taken at the routine sampling stations and duplicated with the July 11 samples for comparison. A total of 1,287 fish were recovered at the mile 76.7 station. Sculpins comprised 71.2 percent of the total fish collected and trout 16.5 percent of the sample. Trout totaled 212 of which five were from the 9.44-inch catchable group and the rest were 3.77-inch fingerlings stocked in March. At the lower station (mile 70.2), 100 fish were collected of which 27.0 percent were trout. Hogsucker, logperch, carp, and sculpin comprised 64.0 percent of the total. Banded darter and whitetail shiner made up the rest of the inventory.

A last sample was taken by electrofishing to evaluate the critical low D.O. levels in the fall of the year. Only one trout was taken out of a total of 238 fish.

Fish population sampling carried out in July indicated a significant difference in the condition factor of the evenly dispersed 3.77-inch fingerling group. The trout stocked at mile 76.7 averaged 0.215 pounds and had a condition factor of 51.37. Trout stocked at mile 70.2 averaged 0.159 pounds and had a condition factor of 38.36. This significant difference in weight and condition indicated either less food was available at the lower station or else food utilization was impaired. Optimum water conditions are reduced by the influx of silt at the lower sampling station which flows into the tailwaters from Coal Creek at mile 75. Investigators theorized that the introduction of turbidity from Coal Creek may have repressed feeding activities of trout sampled at the lower station. Thus, turbidity could have been a significant factor in causing the difference in condition and weight of trout sampled at the two stations.

Later samples were taken at the two stations in October to compare with July samples. The condition factor of trout at the two stations were now found to be about the same due to a loss in condition of trout sampled at the upper station. It was theorized that either a reduction in food or its utilization may have been involved. During the fall of the year, there is a critical low dissolved oxygen period below Norris Dam. This critical D.O. period may have been an intervening factor in food utilization. Also, fish sampling indicated a gross influx of sculpins into the upper station which may also have been a contributing factor to condition loss of trout at this station.

Localized stocking of the catchable size 9.44-inch trout resulted in immediate dispersal as indicated by tag returns. Upstream movement was more pronounced than downstream movement. It appeared useless to stock catchable size trout in one location to attract fishermen due to immediate depletion of the population as a result of their dispersal.

Fish population sampling of the two groups of trout stocked in March and July indicated a better utilization of the resource by the stocked 3.77-inch fingerlings than by the 9.44-inch stocked catchable size trout. The 3.77-inch fingerlings doubled in length during the first four months after their release averaging 0.734 inches per month. The 3.77-inch fingerlings were compared with the 9.44-inch catchable from the time they were stocked in July to the sampling period in October. During this period, the 9.44-inch catchable size trout grew 0.90 inches averaging 0.325 inches per month with a condition factor of 35.48. The 3.77-inch fingerlings for the same period gained 1.37 inches at 0.44 inches per month with a condition factor of 40.72. From these results, it appeared to investigators that there is no benefit in raising trout to a large size in the hatchery for stocking the Norris tailwaters.

<u>Fish Population Samplings During Critical Low D.O. Levels</u>

D.O. concentration reached a minimum of 1.5 ppm during the critical oxygen period of 1971. During this period the TVA River Control Branch routinely incorporates daily shutoffs and D.O. levels build up as the water moves downstream. In order to investigate the possibility that trout may emigrate downstream during critical low D.O. periods in search of better oxygen conditions, five areas were sampled below the end of the study area at mile 66.0. Water sample results showed that reoxygenated water had not reached the lower river below the study area within a 12-hour shutdown period.

Forty-eight percent of the fish sampled were collected within mile 66.0. Due to fish population sampling results and the extended range of low oxygen downstream from the study area, it was concluded there appeared to be no evidence or reason for trout to emigrate very far below the 14-mile study area during low D.O. periods in the fall of the year.

Water Chemistry, Bottom Fauna, and Food Habit Samplings

Seven sampling stations were used for bottom fauna and water chemistry sampling (Table 4). Bottom fauna standing crop was high at all seven sampling areas. The average was 521 organisms per square foot. Tendepedids, amphipods, and isopods comprised 90 percent of the population (Table 5). Bottom fauna diversity was low throughout the study area but increased downstream probably due to higher D.O. levels as released water proceeded downstream.

The chemical water quality of the Norris tailwaters was suitable for trout except for the low oxygen period in the fall and occasional high turbidity below Coal Creek. Low levels of dissolved oxygen below four ppm extended from September 1 to November 25 reaching a minimum of 1.5 ppm immediately below the dam. Oxygen levels remained below 4.5 ppm for nine miles downstream during the most critical period. Water hardness was high (120 ppm), CO_2 ranged from 10 to 15 ppm, pH ranged from 6.8 to 7.4, and there was no adverse concentrations of heavy metals.

Food habit sampling results showed that trout fed predominately on aquatic insects, mainly Tendepedid larvae and pupae. Three large trout collected from earlier stockings made by the Tennessee Game and Fish Commission had consumed fish. None of the trout collected from the 1971 stockings contained fish in their stomachs. Trout collected did not feed upon isopods and amphipods in proportion to their population abundance. All trout stomachs contained algae for which no reasonable explanation could be given except that algae may be consumed during feeding activities in attempts to consume invertebrates which survive in algae communities.

Project Investigations (1972)

Project activities in 1972 consisted of fish population samplings in February, July, and October, a partial creel census, continued bottom fauna and food habit studies; evaluation of water quality and stocking of another sized group of trout.

Stocking

From March 23, 1972, to May 25, 1972, 150,002 six-inch (fork length) rainbow trout were stocked (Table 2). This group was distributed uniformly by boat from the dam to mile 66.0. A large size variation existed in this lot of trout. Considerable time was spent grading and some of the trout had to be held over at the hatchery to gain additional growth. This resulted in the extensive stocking period of two months and a size variation among individual fish samples from the group later in the year.

Fish Population Sampling (Table 3)

The first fish population samples were taken in February at the routine sampling sites located at miles 70.2 and 76.7. Few warm water species were collected due to the cold water temperatures. This sample did result in showing that the 3.77-inch fingerlings stocked in March of 1971 had survived and grew well through the low oxygen period in the fall of 1971. These 3.77-inch fingerlings had grown 1.67 inches and their condition factor had increased almost 15 percent from the time of the last sample in October of 1971.

A second fish population sample was taken in July of 1972. The two routine sampling sites were used at mile 70.2 and mile 76.7 with the addition of another station at mile 66.5. More warm water species of fish were taken in this sample but they were proportionally more abundant at the lower area stations.

Fish population samples were taken at miles 76.7 and 66.5 in October. Mile 70.2 was omitted due to turbidity introduced from Coal Creek above the sampling station. As with the 1971 samples a higher portion of sculpins were noted in the fall samples as compared with samples taken in the spring and summer. Investigators have made no determinations as to the reason for their seasonal fluctuations in abundance.

The six-inch trout stocked in the spring of 1972 were well represented at each station during the October samples. The length increment since the July samples was 0.95 inches at the upper station and 1.01 inches at the lower station. As was noted with the 3.77-inch fingerlings stocked in March of 1971, the six-inch trout stocked in the spring of 1972 declined in condition during the fall. Condition factor declined 6.3 percent at the upper station and 9.2 percent at the lower station.

Comparing the growth of the 3.77-inch fingerlings stocked in March of 1971 to the growth of the six-inch trout stocked in the spring of 1972, it appears that nothing is gained by rearing fish to the larger size at the hatchery before stocking. The 3.77-inch fingerlings grew to 8.85 inches from the time they were stocked in March of 1971 to the last sample taken in October of 1971. Comparing the growth of the six-inch trout for the same time period in 1972, they grew to 8.79 inches. Thus, the 3.77-inch fingerlings surpassed the six-inch fish in growth by 0.06 inches at the time of the last samples taken in October.

Bottom Fauna

Bottom fauna sampling stations were reduced to station one, three, five, and seven. Bottom samples were taken three times - July, September, and late November. The four square-foot samples taken in 1971 were changed to eight square-foot samples at each station in 1972.

Bottom fauna numbers were down 30 to 40 percent from 1971 (Table 5). Tendipeds comprised over 80 percent of the samples taken in 1972 and simulids increased considerably over 1971. Caddis flies decreased in composition but stone flies and mayflies increased and stone flies were prevalent enough to be considered as an established part of the population. Sampling indicated that March was the major month for expansion of bottom fauna populations and trout should be stocked early enough to take advantage of this.

Stomach Sample Analyses

Tendipeds continued to make up the major portion of the food base, but isopods and simulids were also heavily used during feeding activities. Stomach samples also revealed a heavy ingestion of algae and reasons for consumption continued to remain a puzzle. Though diversity is limited, a good food base seems to exist in the tailwater area and all organisms except amphipods were represented in the stomach samples. Investigators concluded from bottom fauna sampling and stomach analysis that stocking could continue at its present level without harm to the food base.

Water Quality

Water quality remained high and conducive to trout management and development except for two major exceptions as encountered in 1971. The influx of silt from Coal Creek and the low D.O. concentration in September and October continued to be a major factor in lowering water qualities as related to trout management.

Phase II 1973

Investigational activities in 1973 included the activation of a full time creel census, continued bottom fauna and trout food habit studies, continued monitoring of water quality, and stocking of 7.85-inch fork-length trout.

Stocking

Trout stocked in 1973 were divided into two subgroups and marked differently by fin clipping (Table 2). This was done to test the value of dispersing trout uniformly throughout the 14-mile river section. Part of the group containing 24,564 trout were marked by clipping the right ventral and adipose fins (RVAd). This group was stocked by truck at a central point 5.2 miles below the dam. The second part of the group containing 23,726 trout were marked by clipping the left ventral and adipose fins (LVAd) and dispersed uniformly throughout the 14-mile study area by boat.

Trout Movement and Distribution

The 1973 creel census returns reflected trout movement and distribution. The first half of 1973, mile areas 75.0 and 77.0 represented the most fishing effort and the greatest catch. At mile 78.0, less effort was put forth and the catch was lower but the catch rate was relatively high. During the second half of the year, the catch at mile 75.0 dropped from 42.9 percent to 6.6 percent. Conclusions were that the lower catch rate may have resulted from the RVAd trout dispersing upstream. This conclusion is supported by the fact that even though less effort was made by fishermen at mile 76.0 the catch rate was the same as in the first half of the year. Also, at mile 78.0 the effort did not increase but the catch rate increased from 14.9 percent the first half of the year to 33.1 percent the second half.

Further evidence of trout movement was shown by the monthly creel returns from the two groups of trout stocked early in 1973. The RVAd trout stocked at mile 75.0 remained fairly stationary until April when over 70 percent of their catch was recorded above mile 75.0 By the end of 1973, 84.5 percent of the RVAd trout were caught from mile 75.0 to mile 79.0 and 15.5 percent were caught from miles 66.0 to 74.0. The catch of the LVAd group dispersed uniformly throughout the study area was similar. From mile 75.0 to 79.0, 85.7 percent were caught and from mile 66.0 to 74.0, 14.3 percent were caught. From the results, it was evident that little was gained by dispersing the LVAd group throughout the 14-mile study area.

The 1973 creel census returns also gave some indication of survival and growth rates of trout groups stocked in 1971 and 1972. Of the total number of trout returns in 1973, 77.8 percent were from the 8-inch groups stocked in 1973, but the residual groups stocked in 1971 and 1972 comprised almost half of the total weight harvested.

Fish Population Sampling (Table 3)

Five fish population samples were taken from January to October of 1973 using cyanide and electrofishing gear. Nontrout species were represented by a higher percentage in numbers but trout comprised the higher percentage by weight. Sculpins were in higher numbers than all other nontrout species during all samples but large suckers made up the bulk of total weight during the October samples.

The two groups of trout (LVAd and RVAd) stocked in 1973 were well represented at the three routine sampling stations during the March sampling period. All three-year classes were sampled at the three sampling stations during June with 27.3 percent of the total sample consisting of residuals from the 1971 and 1972 stockings and 72.7 percent from the 1973 stocking. A later sample in July was taken only at the upper station due to turbidity at the two lower stations. The sample consisted of 93.4 percent nontrout species which were mostly sculpins. Fifty-five trout were collected during this sampling period of which four were wild unmarked trout. This represented the first recorded evidence of natural reproduction by trout associated with the tailwater. These four wild trout were yearlings averaging 4.45 inches. A last sample taken in October at mile 76.7 and mile 70.2 showed an increase in nontrout species possibly due to an increase in water temperature. Sculpins were the predominant nontrout species. Another wild trout measuring 6.7 inches was also taken at the upper station.

In order to establish the source of wild trout collected during July and October, Clear Creek, at mile 78.0, was sampled in December using cresol in the embayed water near the mouth and electrofishing upstream. Three unmarked ripe adults ranging from 1.5 to 2.0 pounds and five wild juvenile rainbows were recovered. The juvenile trout were apparently progeny from natural spawning and it was assumed those wild trout collected at the upper station had emigrated from Clear Creek.

From results of population samples and creel census, it was evident that a repressed growth of trout had occurred in the early part of 1973. Also, for the same time period, a reduction in bottom fauna was found to occur particularly with the Tendipedids, the major food item for trout in the tailwaters. Investigators assumed that extreme river flows which occurred through December and early January were responsible for the detrimental effects to the aquatic resource. However, later evidence of recovery of bottom fauna populations and increased trout growth and condition indicated that the effect from high flows was temporary.

Further evidence of slowed growth in the 1973 group of stocked trout was found in the October sample. Growth rates decreased 67.0 percent and they experienced an 11.0 percent condition loss. Decreased growth rates and condition loss were also experienced by former groups in October of 1971 and 1972, and it seemed reasonable to suspect that the typical oxygen deficiency during the fall of the year was responsible for the changes in fish growth.

Bottom Fauna

Bottom fauna communities continued to be characterized by low diversity but good production (Table 5). Low D.O. levels are probably the most important contributing factor to low diversity. The general form of the community had persisted throughout the three years of study but there had been some major shifts in taxonomic composition. Standing crop of bottom fauna showed an annual pattern of expansion in late winter and early spring and a pronounced "crash" in early winter. In 1973 the "crash" lasted longer than usual but recovery was also greater so bottom fauna fully recovered. Reasons for these "crash" and recovery cycles are unknown.

Stomach Analyses

Ingestion of amphipods increased during 1973. However, though bottom fauna samples regularly contain amphipods, they still were not as numerous in trout stomachs as might be expected. It has been proposed that their nocturnal drifting habits offer some protection and may inhibit trout predation. Four items composed the majority of trout food regularly taken. Midges dominated, numerous numbers of simulids are consumed, and isopods and amphipods although not numerous in stomachs were regularly taken. Data indicated that volumes of algae were still regularly ingested but the reasons for this feeding behavior remained unknown.

Water Quality

Water quality remained high in 1973 except for heavier amounts of silt inflowing from Coal Creek, and continued low D.O. levels throughout the tailwater in late August, September, and October.

Table 1

TROUT STOCKING IN CLINCH RIVER (1962-1970)

Rainbow	1962	1963	1964	1965	1966	1967	1968	1969	1970
3-4 in.	78,000	25,000	30,000	50,000	25,000	39,500	75,000	25,000	14,500
6-7 in.						30,750	26,000	12,800	
8-10 in.						5,500			11,200
11-12 in.			1,000		4,450	2,000			

Table 2

TROUT STOCKING RECORD - NORRIS TAILWATER (Dam - 14 miles)

Date	Species	Mark	Number	Total Wt. Pounds	No./lb.	$\bar{x}$ F.L."	Truck Loads	Area and Method
3/2 - 17/71	RBT	RV	142,000	3,919	36.23	3.77	4	Mi 1-14 - By Boat
7/13 - 14/71	"	Bluetag	4,963	1,654	3.0	9.44	2	Mi 10 - By Boat
3/23 - 4/7/72	"	LV	75,750	7,181	10.55	6.05	7	Mi 1-14 - By Boat
4/26 - 5/25/72	"	LV	74,252	5,970	12.45	5.86	5	Mi 1-14 - By Boat
TOTAL			150,002	13,151	11.41	5.97	12	Mi 1-14 - By Boat
1/29-31/73	RBT	RVAd	24,564	4,832	5.08	7.89	3	I-75 Bridge Mile 6 By Truck
1/29-2/1/73	"	LVAd	23,726	4,965	4.78	7.83	5	Mi 1-14 - By Boat
TOTAL			48,290	9,797	4.93	7.85	8	
1/22 & 1/23/74	"	Red Tag	7,462	2,017	3.70	8.56	1.5	Mi 2
1/22 & 1/23/74	"	Blue Tag	7,380	2,079	3.55	8.84	1.5	Mi 9
TOTAL			14,842	4,094	3.63	8.70	3	
3/4 - 7/74	"	Ad	244,285	6,174	39.57	3.98	6	Mi 1-14 - By Boat

TABLE 3

SUMMARY OF FISH COLLECTED BY ROTENONE, CYANIDE, ELECTROFISHING, AND GILL NETTING FROM FEBRUARY 1971 TO OCTOBER 1973

Species	Number			
	1971	1972	1973	Total
Sculpin	954	470	2,207	3,631
Rainbow Trout	1,293	1,932	186	3,411
Gizzard Shad	299	5	1	305
Carp	149	32	3	184
Hogsuckers	78	29	68	175
Logperch	40	75	35	150
Redhorse	43	23	51	117
Quillback	30	11	71	112
Stoneroller	7	13	50	70
Forage Species (1971)	52	-	-	52
Brook Silversides Sculpin Logperch				
Smallmouth Buffalo	12	4	2	18
Bluegill	6	6	4	16
Carpsucker	4	-	9	13
Drum	1	2	9	12
Rock Bass	1	5	1	7
Greenside Darter	-	2	3	5
White Sucker	5	-	-	5
Whitetail Shiner	5	-	-	5
Blacknose Dace	-	1	3	4
Channel Catfish	1	-	3	4
Sauger	3	-	-	3
Bluntnose Minnow	-	2	-	2
Redbreast Sunfish	-	1	1	2
Brook Silversides	-	-	1	1
Common Shiner	-	1	-	1
Threadfin Shad	-	1	-	1

Table 4

NORRIS TAILWATER BOTTOM FAUNA AND
WATER CHEMISTRY SAMPLING STATIONS

Station I (CRM 79.5) - Shoal across from riprap immediately below the dam. Dense growth of brownish algae. Bedrock predominates, but adequate amounts of rubble and small boulders are present for bottom fauna sampling.

Station II (CRM 78.0) - Shoal immediately below the influence of Clear Creek. Gravel and small boulders are the major constitutients of the substratum.

Station III (CRM 77.1) - Shoal at the upper tip of Miller's Island. Samples are taken on both sides of the upper tip. Gravel, sand and small boulders predominate. Bedrock not encountered in sampling. Evidence of fairly heavy sedimentation.

Station IV (CRM 75.8) - Shoal immediately above Massengill Bridge. Bedrock and "hogbacks" are the predominating substratum with some rubble and boulders where the current forms a chute through the ridges of bedrock.

Station V (CRM 73.2) - Shoal about 1/4 mile below the first farm buildings on the left after leaving Coal Creek. Ridges of bedrock occur above riffles of sand, gravel and small boulders.

Station VI (CRM 70.5) - About one mile below the influence of Caney Creek. Ridges of bedrock occur above strong rapids which quiet somewhat into fast, deep riffles or small rapids.

Station VII (CRM 66.6) - About 1/2 mile above the 61 Bridge. Ridges of bedrock alternate with small rapids and riffles. Gravel and small boulders predominate.

TABLE 5

Mean Number of Bottom Fauna *Per Square Foot at
Miller's Island Station (Mile 3.3) Norris Tailwater

Year	Tendipedidae				Isopoda Lirceus	Amphipoda Gammarus	Hydracarina	Planeriidae	Simuliidae	Total
	Larvae	Pupae	Adult	Total						
1971 Qtr.										
I	778.0	30.3		803.3	54.1	11.6	6.0	2.0	4.0	881.
II	499.3	31.9		531.2	22.6	58.5	T	T		612.
III	806.8	71.8		878.6	35.8	80.6	6.5	T	2.1	1,003.
IV	477.6	6.1		483.7	50.3	15.3	8.0	T		557.
1972										
I	525.0	71.4		596.4	71.4	15.8	17.1	T	13.4	714.
II	355.8	41.0		396.8	3.7	19.5	2.0		2.0	429.
III	-	-	-	-	-	-	-	-	-	-
IV	356.0	51.6		407.6	94.8	26.9	51.2	10.9	7.1	598.
1973										
I	20.1	T		20.1	4.7	12.9	34.7	1.9	5.3	79.
II	77.8	3.0		80.8	14.5	146.0	22.5	6.0	2.0	271.
III	357.0	39.1	25.0	396.1	23.3	43.6	44.5	21.9	12.0	550.
IV	248.2	13.5		261.7	20.5	92.7	12.2	36.5	3.8	427.

*Trace amounts of other species omitted.

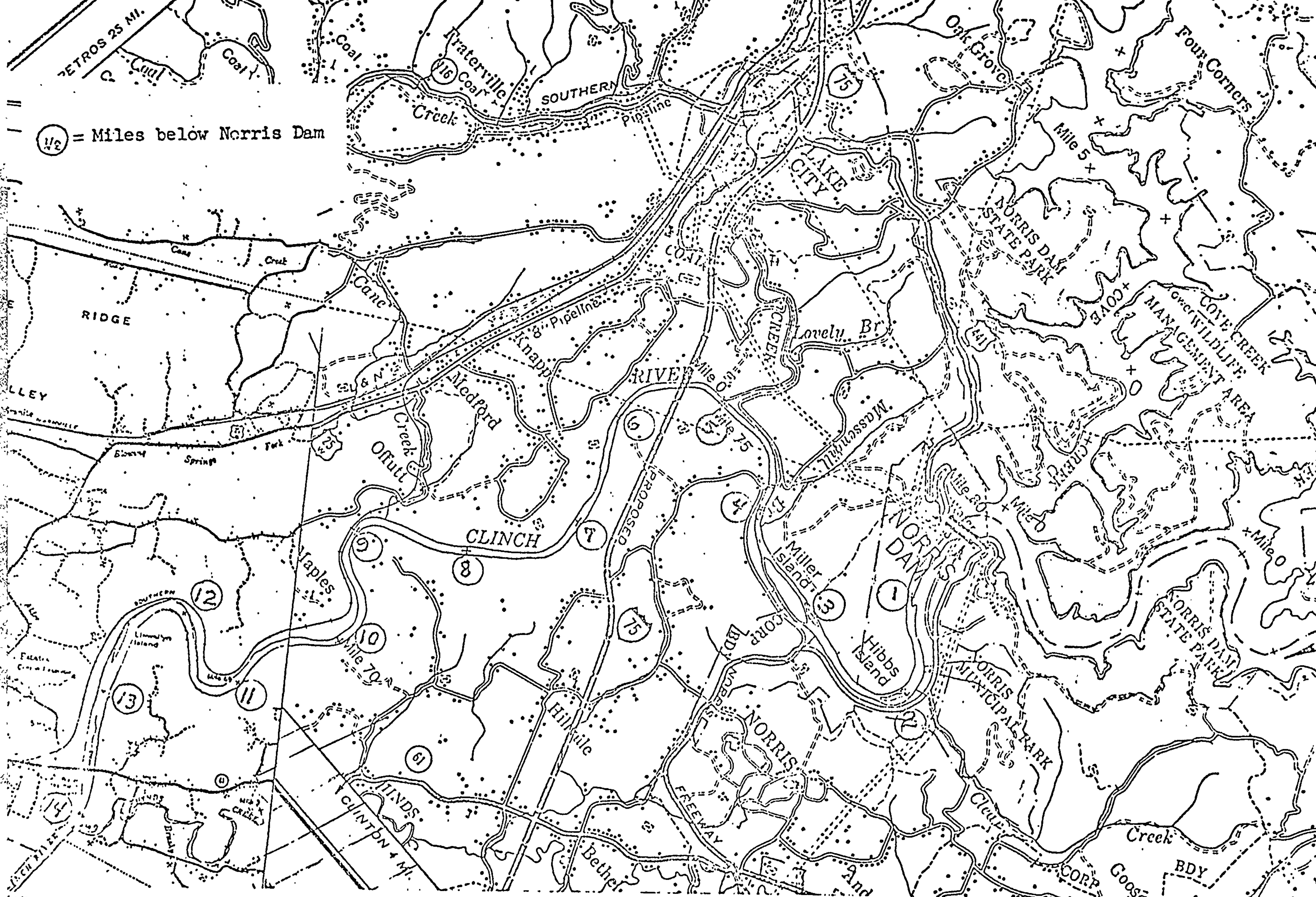

Fig. 1. Clinch River (Norris Tailwater) showing 14-mile study area

FUTURE PROPOSALS

Future plans and activities as outlined by the fourth annual cooperative trout management planning session for Norris Dam tailwaters in 1973 are as follows:

1. Creel census and the necessary fishery studies through 1976 to evaluate the recent stocking and "split" stocking contemplated in the winter of 1974 and spring 1975.
2. Plans were proposed to meet with TVA Power Branch and coordinate a flow schedule to test various flows. With flow regulation, additional limnological studies will be required to evaluate affect on bottom organism production.
3. 1974 stocking will be 242,000 rainbow trout fingerlings evenly scattered throughout the entire area.
4. Preliminary chemical data and trout distribution will be determined for Melton Hill Reservoir and the tributaries to the tailwater.
5. Exclosures will be designed and tested for effectiveness of evaluating trout/bottom fauna relationships.
6. Methods will be devised for collecting trout stomachs at all tailwater flow rates including sluicing.
7. Algae measurements will be included in all future bottom fauna sampling.
8. The amount of river bottom exposed during turbine shutoff will be determined and the potential bottom fauna loss which may result will be estimated.
9. A proposal will be prepared to justify optimum flows for weekend trout fishing success and presented to TVA Reservoir Planning meeting in March 1974.

10. Stream rehabilitation of Clear Creek for improved natural trout reproduction will be discussed with the State Park Department.

11. Brown versus rainbow trout stocking in a tailwater will be evaluated.

SUMMARY

Fisheries Data

Low D.O. levels in the fall, high turbidity at the lower stations, and Cottid competition appeared to affect trout growth and condition. Silt from Coal Creek may at times limit visibility and thus inhibit feeding success. There appears to be an influx of sculpins into the Norris tailwater in the fall of the year. This competition may limit food available to trout especially where the food supply is limited at the upper stations. No determinations have been made as to the reason for their seasonal fluctuation in abundance. Low D.O. levels seem to limit food utilization by trout especially at the upper stations. Low dissolved oxygen did not cause migrations of stocked trout from the managed area.

Fish Population Sampling

Nontrout species were collected in larger numbers, but trout made up the higher percentage in weight of most collections. Nontrout species consisted largely of sculpins, carp, and gizzard shad. Other nontrout species sampled were channel cat, redhorse, hogsuckers, white suckers, rock bass, brook silversides, logperch, bluegill, stone roller quillback, smallmouth buffalo, and sauger. Four wild yearling trout were collected at the upper station in July of 1973. This was the first recorded evidence of natural reproduction in the Norris tailwaters.

Stocking

Four-inch, six-inch, eight-inch, and nine-inch trout were stocked from 1971 to 1973. Conclusions are that a four-inch trout is the best size for stocking the Norris tailwaters. They suffered little predation, are low cost, grow well, maintain good condition factors, and are more efficient in adapting to and utilizing natural foods for growth. Larger fish appear to have more difficulty in adjusting to river conditions.

Bottom Fauna

Tendipedids, amphipods, and isopods comprise 90 percent of the bottom fauna population. Mayflies, stone flies, and caddis flies are also present. The bottom fauna community is characterized by low diversity but good production. Stress placed on the communities by low D.O. levels is probably the most important contributing factor to low diversity. The standing crop of bottom fauna shows an annual pattern of expansion in late winter and early spring and a pronounced "crash" in early winter. The "crash" of early winter and the subsequent recovery pattern of late winter suggest that March and April are the best times for stocking.

Stomach Analyses

All stomach analysis is based on stomachs collected during periods of low flows. Stomach samples from periods of high flow are needed for comparison Trout fed predominantly on aquatic insects, mainly Tendipedid larvae and pupae. Simulids, isopods, and amphipods were also consumed. All stomach samples contained algae. No apparent reason could be given for ingestion of algae by trout.

Water Quality

Water quality remained high for the production and maintenance of a trout population, except for silt introduced into the tailwater from Coal Creek and periods of low D.O. levels in the fall of the year. Future management plans may hinge largely on the detrimental affects silt and low D.O. levels have on the Norris tailwaters.

TEB:KG
1-14-75

TVA Chattanooga

FISH INVENTORY DATA
FORT LOUDOUN RESERVOIR
1972

Tennessee Valley Authority
Division of Forestry, Fisheries, and Wildlife Development
Norris, Tennessee

April 1973

Introduction

This report contains recently gathered information on fishes living along the shoreline and in the coves of Fort Loudoun Reservoir. It gives the result of sampling studies done during August and September 1972 by the Tennessee Valley Authority, with assistance from the Tennessee Game and Fish Commission.

Technical data presented will be used by various agencies involved with fish management and fishery resource development. They should be helpful to biologists called on to investigate fish kills or other effects of changes in water quality, to evaluate the introduction of exotic fish into the reservoir, and to assess the impact of any future changes in this lake or on its watershed.

Specific data reported here reflect the number, size, mass, and variety of species found and indicate reproductive success of the various fishes which inhabited the cove and shoreline areas of Fort Loudoun Reservoir in 1972. This littoral zone is the most productive; it is where most fish and fishing activity occurs,and where the most representative fish population samples can be taken in a large lake.

This report was prepared by TVA biologist, Tommy L. Sheddan.

FISH INVENTORY DATA
FORT LOUDOUN RESERVOIR

Sample Areas and Procedures

Fort Loudoun Reservoir is an impoundment on the upper mainstream of the Tennessee River. The dam, in Loudon County, Tennessee, is at Tennessee River Mile 602.3, about 45 miles downstream from Knoxville, Tennessee. At full pool (elevation 813 msl) Fort Loudoun Reservoir has a total surface area of 14,600 acres. During the sample period, August and September 1972, lake elevation fluctuated between 812.1 and 812.6 msl; reservoir area varied between 14,240 and 14,440 surface acres; and surface temperatures in the top six inches of water varied between 76° F and 82°F.

No coves adequate for sampling were found above the mouth of Little River, TRM 625. The remainder of the reservoir was divided into four major areas (see map) and two coves sampled in each area (Table 1). Cove size ranged from .93 to 1.6 surface acres (.38 ha to .65 ha), average depth from 3.2 feet to 8.8 feet (1.0 to 2.6 m). Water quality data collected from surface to bottom in these coves ranged as follows: Dissolved oxygen - 3.0 to 12.0 mg/l; CO_2 - less than 5.0 to 10.0 mg/l; temperature - 23.4 to 27.8°C; pH - 7.5 to 9.1; conductivity - 210 to 320 micromhos/cm; phenolphthalein alkalinity - 0 to 17.1 mg/l; total alkalinity - 85.5 to 119.7 mg/l; total hardness - 85.5 to 102.6 mg/l. Similar data for the adjacent river channels are presented in Table 2.

Field procedures for treament of each cove and collection of data followed methods accepted for cove rotenone samples throughout the Southeast. Coves are blocked with nets and treated at the rate of 1 ppm with 5% emulsifiable rotenone; fish are picked up for two days. A complete list of the fishes found in this inventory is given in Table 3; size classes and subsamples used in data analyses are shown in Table 4.

Summary of Findings

<u>Average cove population</u>—4,816 fish and 361 pounds per surface acre—11,900 fish and 404.8 kilograms per hectare (Table 5).

<u>Major fish classes by number</u>—game 19 percent, rough 3 percent, forage 78 percent (Tables 6 and 9).

<u>Major fish classes by weight</u>—game 13 percent, rough 34 percent, forage 53 percent (Tables 6 and 9).

<u>Dominant species by number</u>—gizzard shad 37 percent, threadfin shad 32 percent, bluegill 15 percent, and assorted forage 8 percent (Table 7).

<u>Dominant species by weight</u>—gizzard shad 48 percent, carp 19 percent, bluegill 9 percent, and smallmouth buffalo 8 percent (Table 7).

<u>Size distribution of game fish by number</u>—young-of-year 44 percent, intermediates 41 percent, harvestable (adults) 15 percent (Tables 8 and 9).

<u>Size distribution of all fish by number</u>—young-of-year 64 percent, intermediates 9 percent, harvestable (adults) 27 percent (Table 9).

<u>Spawning success</u>—good survival of young-of-year shad, bluegill, and largemouth bass; young-of-year numbers of other species were low.

<u>Growth of fish</u>—Growth of largemouth bass and bluegill taken in 1972 was better than that found in the 1961 inventory; white crappie growth was faster in 1961.

<u>Marked fish</u>—196 recovered of 292 marked for 67% recovery (Table 11).

General Conclusions

Comparable standing crop data for 1972 and 1961, the last time Fort Loudoun Lake was sampled, are available for only one cove. Area I, Cove 1 (Pickel Hollow) was sampled in both years.

Numbers of game fish per acre were similar in both years. The standing crop of game fish was up 108% in 1972; rough fish numbers per acre decreased 60% from 365 in 1961 to 145 in 1972, but with only a 10 pound per-acre loss. Forage fish numbers per acre in 1961 were 18,958, of which 90 percent were threadfin shad; in 1972 there were 3,735 forage fish per acre, 40 percent of which were threadfin.

The decrease in forage fish may be reflected in the slower growth rate of white crappie in 1972. The following decline in numbers per acre of three important game species may also be related to fewer forage. Sauger decreased from 21 per acre in 1961 samples to a trace in 1972, white crappie from 369 (292 of which were young-of-year) to 12, and channel cat from 47 to 14. On the other hand, numbers of largemouth bass per acre increased from 2 in 1961 to 67 in 1972.

Dissolved oxygen concentrations in the upper 6 meters of water and the number of fish per acre decrease as one moves upstream. This may be the result of improperly treated sewage and industrial waste from the Knoxville vicinity.

Two small paddlefish were found outside the net in Area IV, Cove 1. This species is rarely taken in Tennessee Valley population studies, but they were also taken in the 1961 sample.

Fort Loudoun Reservoir in 1972 had a larger standing crop of fish than most comparable TVA mainstream impoundments—only Wheeler and Pickwick had bigger crops in the last 12 years—with the biomass distributed primarily among adult gizzard shad, carp, and buffalo.

Literature Cited

Inventory of Fish Populations, Fort Loudoun Reservoir, 1961. TVA. Fish and Wildlife Branch. 30 pp.

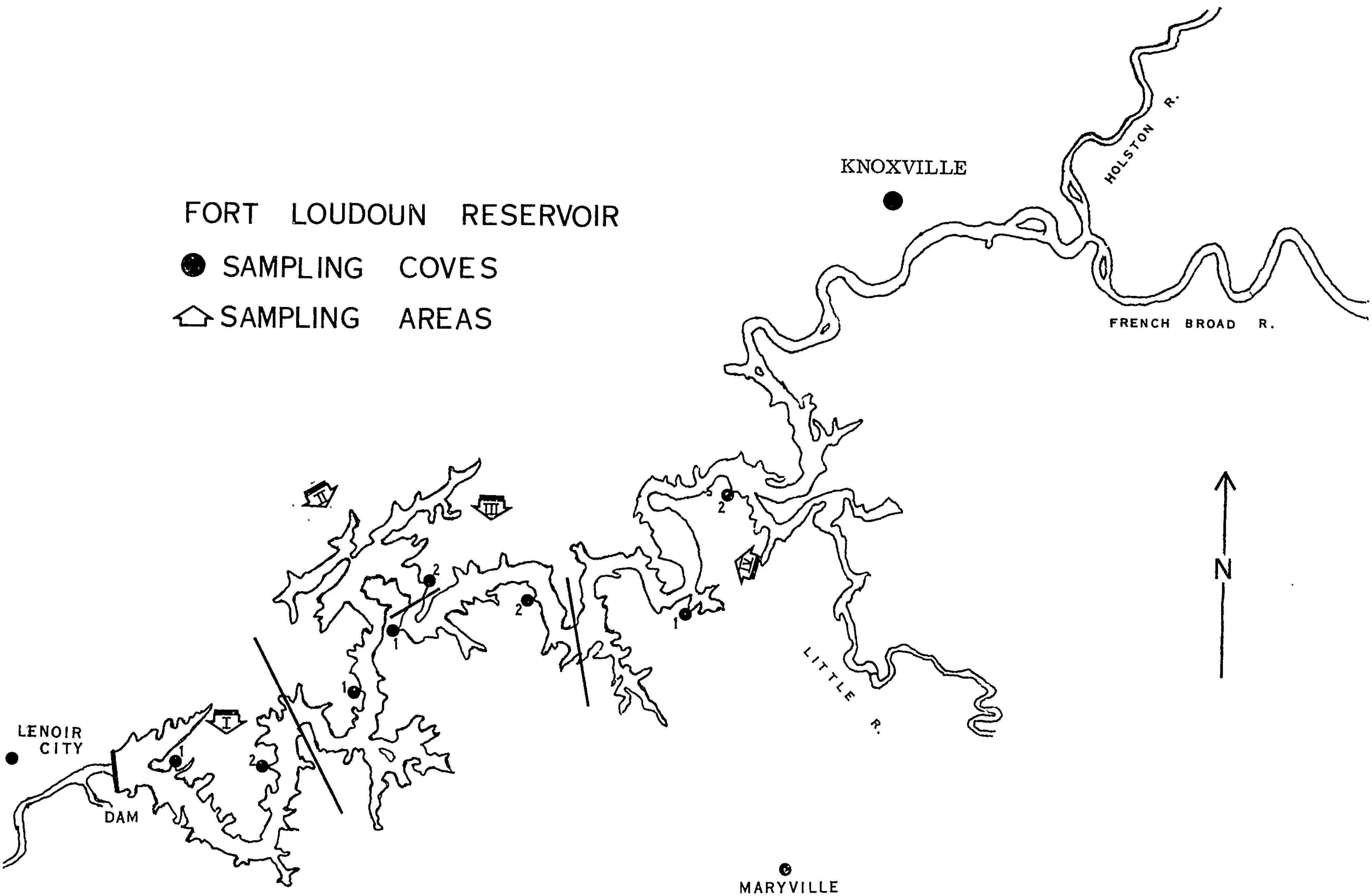
FORT LOUDOUN RESERVOIR
SAMPLING COVES
SAMPLING AREAS
KNOXVILLE
HOLSTON R.
FRENCH BROAD R.
LITTLE R.
MARYVILLE
LENOIR CITY
DAM
N
I
II
III
IV
1
2

Table 1. SAMPLE AREA LOCATIONS, FORT LOUDOUN RESERVOIR, 1972

AREA I	
Cove 1	TRM 603.6, right bank;* left hand prong that lies NW.
Cove 2	TRM 608.3, right bank; right hand prong that lies NNW.
AREA II	
Cove 1	TRM 613.3, right bank.
Cove 2	TRM 618.1, right bank.
AREA III	
Cove 1	TRM 619.4, left bank.
Cove 2	TRM 623.7, left bank; the longest prong of the cove which lies W.
AREA IV	
Cove 1	TRM 629.7, left bank; the first cove after entering George's Creek from the river. The cove lies SW.
Cove 2	TRM 635.3, left bank; the first cove after entering Little River from the Tennessee River. The cove lies SSW.

*Left and right banks are indicated when facing downstream.

Table 2. WATER QUALITY DATA, RIVER CHANNEL, FORT LOUDOUN RESERVOIR, 1972

Depth Meters	Channel Area I September 6			Channel Area II August 22			Channel Area III August 30			Channel Area IV August 28		
	Temp. °C	DO mg/l	CO_2 mg/l	Temp. °C	DO mg/l	CO_2 mg/l	Temp. °C	DO mg/l	CO_2 mg/l	Temp °C	DO mg/l	CO_2 mg/l
Surface	25.5	10.0	5.0	26.6	12.0	*	25.5	8.0	5.0	25.3	7.5	5.0
3	24.5	9.0	5.0	25.0	11.0	5.0	23.9	6.0	10.0	23.9	6.0	10.0
6	24.5	6.0	5.0	23.4	5.0	10.0	23.4	5.0	10.0	23.4	4.0	10.0
9	23.9	3.0	10.0	23.4	5.0	15.0	23.4	5.0	10.0	22.8**	4.0	10.0
12	23.4	3.0	10.0	23.4**	4.0	15.0	23.1	5.0	10.0			
15	23.4	3.0	10.0				23.1**	5.0	12.5			
18	23.4	3.0	10.0									
	23.4**	2.0	10.0									

*Less than 5.0 mg/l

**Last reading in each column taken at these depths:

19.7 meters   10.6 meters   14.7 meters   7.8 meters

Ranges of additional chemical data collected in the main channel:

pH—7.2 to 9.2
Conductivity—225 to 310 micromhos/cm
Phenolphthalein alkalinity—0 to 17.1 mg/l
Total alkalinity—85.5 to 128.2 mg/l
Total hardness—85.5 to 102.6 mg/l

Table 3. COMMON AND SCIENTIFIC NAMES* OF FISHES IN ROTENONE SAMPLES - FORT LOUDOUN RESERVOIR, 1972

Game

White bass (Morone chrysops)
Redbreast sunfish (Lepomis auritus)
Warmouth (Lepomis gulosus)
Bluegill (Lepomis macrochirus)
Longear sunfish (Lepomis megalotis)
Smallmouth bass (Micropterus dolomieui)
Spotted bass (Micropterus punctulatus)
Largemouth bass (Micropterus salmoides)
White crappie (Pomoxis annularis)
Black crappie (Pomoxis nigromaculatus)
Sauger (Stizostedion canadense)

Rough

Skipjack herring (Alosa chrysochloris)
Carp (Cyprinus carpio)
Quillback (Carpiodes cyprinus)
White sucker (Catostomus commersoni)
Smallmouth buffalo (Ictiobus bubalus)
Golden redhorse (Moxostoma erythrurum)
Shorthead redhorse (Moxostoma macrolepidotum)
Yellow bullhead (Ictalurus natalis)
Brown bullhead (Ictalurus nebulosus)
Channel catfish (Ictalurus punctatus)
Flathead catfish (Pylodictis olivaris)
Drum (Aplodinotus grunniens)

Forage

Gizzard shad (Dorosoma cepedianum)
Threadfin shad (Dorosoma petenense)
Goldfish (Carassius auratus)
Silver chub (Hybopsis storeriana)
Golden shiner (Notemigonus crysoleucas)
Emerald shiner (Notropis atherinoides)
Whitetail shiner (Notropis galacturus)
Steelcolor shiner (Notropis whipplei)
Bluntnose minnow (Pimephales notatus)
Blackstripe topminnow (Fundulus notatus)
Brook silversides (Labidesthes sicculus)
Logperch (Percina caprodes)

*From American Fisheries Society Publication Number 6, third edition, 1970

Table 4. SIZE CLASSES* AND SUBSAMPLES USED IN 1972 FISH INVENTORIES

Species	Young-of-year	Intermediate	Harvestable
	- - - - - - - - - - - Length in inches	- - - - - - - - - - - -	
Game			
White bass	1-6	7-8	9 and over
Yellow bass	1-6	7-8	9 "
Rock bass	1-3	4-5	6 "
Bluegill	1-2	3-5	6 "
Other sunfishes	1-2	3-5	6 "
Smallmouth bass	1-4	5-8	9 "
Spotted bass	1-4	5-8	9 "
Largemouth bass	1-4	5-9	10 "
Crappie	1-3	4-7	8 "
Sauger	1-8	9-11	12 "
Walleye	1-8	9-11	12 "
Rainbow trout	1-6	-	7 "
Rough			
Gar	1-12	13-19	20 "
Skipjack herring	1-6	7-11	12 "
Mooneye	1-6	7-11	12 "
Carp	1-8	9-12	13 "
Carpsuckers	1-8	9	10 "
Buffalo	1-8	9-12	13 "
Redhorses	1-7	8-10	11 "
Bullhead	1-4	5-7	8 "
Blue catfish	1-5	6-9	10 "
Channel catfish	1-5	6-9	10 "
Flathead catfish	1-5	6-11	12 "
Drum	1-5	6-8	9 "
Forage**			
Threadfin shad	1-5	-	6 "
Gizzard shad	1-5	-	6 "
Miscellaneous forage fishes	-	-	-

*The size class divisions for each species are arbitrary, but based on knowledge of growth rates and information from creel census and commercial harvest records.

**Shad were recorded either as young-of-year or adult; sizes of other forage fish were not differentiated.

Subsamples: Mixed threadfin and gizzard shad (5 inches and less) - 3 pounds
Mixed species other than shad (3 inches and less) - 3 pounds
Sorted individual species (3 inches and less) - 1 pound

Table 5. STANDING CROP OF FISH BY SAMPLE AREA, FORT LOUDOUN RESERVOIR, 1972

Sample Area	Size		Mean depth		No. of fish		Weight of fish	
	Acres	Hectares	Feet	Meters	Acre	Hectare	Pounds/ Acre	Kilograms/ Hectare
Area I								
Cove 1	1.36	0.55	6.8	2.1	5,105	12,615	241.5	270.8
Cove 2	1.1	.45	8.7	2.7	8,724	21,557	326.1	365.7
Area II								
Cove 1	1.0	.40	8.8	2.6	7,236	17,880	198.7	222.9
Cove 2	1.6	.65	7.7	2.3	3,828	9,460	392.9	440.6
Area III								
Cove 1	1.0	.40	4.9	1.5	3,208	7,927	475.2	532.9
Cove 2	1.5	.61	4.7	1.4	4,529	11,192	692.3	776.3
Area IV								
Cove 1	0.93	.38	3.2	1.0	4,386	10,838	203.7	228.4
Cove 2	1.0	.40	5.6	1.7	1,722	4,255	208.2	233.5
All areas	9.49	3.84	6.3	1.9	4,816	11,900	361.0	404.8

Table 6. AREA POPULATIONS FOR MAJOR FISH GROUPS, FORT LOUDOUN RESERVOIR, 1972

Sampling Area Description	Fish Group	Number of Species	Number Per Acre	Pounds Per Acre
Area I				
2 samples	Game	10	931	57.5
2.46 acres	Rough	7	202	88.1
Sept. 5-6, 1972	Forage	7	5,590	133.7
		24	6,723	279.3
Area II				
2 samples	Game	9	1,233	54.8
2.6 acres	Rough	9	100	123.1
Aug. 21-23, 1972	Forage	7	3,806	140.3
		25	5,139	318.2
Area III				
2 samples	Game	9	662	30.5
2.5 acres	Rough	9	155	207.4
Aug. 23-30, 1972	Forage	7	3,184	367.5
		25	4,001	605.4
Area IV				
2 samples	Game	7	899	37.3
1.93 acres	Rough	8	118	61.1
Aug. 28-30, 1972	Forage	8	1,989	107.6
		23	3,006	206.0
All Areas				
8 samples	Game	11	936	45.6
9.49 acres	Rough	12	145	123.6
Aug. 21-Sept. 6, 1972	Forage	12	3,735	191.8
		35	4,816	361.0

Table 7. SPECIES COMPOSITION OF COVE POPULATIONS, FORT LOUDOUN RESERVOIR, 1972

Species	Percent of total number	Percent of total weight
Gizzard shad	37.0	48.2
Threadfin shad	32.2	4.7
Bluegill	15.4	8.5
Assorted forage*	8.4	.3
Drum	1.7	5.8
Largemouth bass	1.4	1.6
Warmouth	1.0	.2
Carp	.7	18.8
Redbreast sunfish	.6	.7
White bass	.4	.3
Smallmouth bass	.3	.3
Channel catfish	.3	1.4
White crappie	.2	.7
Yellow bullhead	.1	.1
Smallmouth buffalo	.1	7.6
Black crappie	.1	.3
Flathead catfish	.1	.5
Skipjack herring	t	t
Sauger	t	t
Shorthead redhorse	t	t
River herring	t	t
Longear sunfish	t	t
Golden redhorse	t	t
Quillback	t	t
Brown bullhead	t	t
White sucker	t	t

t = less than 0.05 percent

* = Includes emerald shiners, bluntnose minnows, logperch, brook silverside, steelcolor shiners, whitetail shiners, blackstripe topminnows, golden shiners, and silver chub.

Table 8. SIZE DISTRIBUTION PER ACRE BY SPECIES, FORT LOUDOUN RESERVOIR, 1972

Species	Young-of-year		Intermediate		Harvestable		Total	
	Number	Pounds	Number	Pounds	Number	Pounds	Number	Pounds
Gizzard shad	699	12.5	*	*	1,081	161.3	1,780	173.8
Threadfin shad	1,523	14.6	*	*	28	2.3	1,551	16.9
Bluegill	300	0.9	324	17.3	119	12.5	743	30.7
Assorted forage	404	1.1	0	0	0	0	404	1.1
Drum	16	0.3	22	2.9	43	17.6	81	20.8
Largemouth bass	50	0.7	14	2.0	3	3.1	67	5.8
Warmouth	28	0.1	19	0.6	1	0.2	48	0.9
Carp	6	0.7	11	3.3	17	63.7	34	67.7
Redbreast sunfish	5	t	13	0.8	10	1.6	28	2.4
White bass	17	0.7	2	0.3	t	0.1	19	1.1
Smallmouth bass	13	0.2	1	0.2	1	0.5	15	0.9
Channel catfish	4	0.1	4	0.6	6	4.2	14	4.9
White crappie	1	t	6	0.5	5	1.9	12	2.4
Yellow bullhead	4	t	1	0.1	1	0.4	6	0.5
Smallmouth buffalo	t	0.1	0	0	5	27.3	5	27.4
Black crappie	t	t	2	0.2	3	1.0	5	1.2
Flathead catfish	1	t	1	0.3	1	1.6	3	1.9
Skipjack herring	1	t	t	t	t	0.1	1	0.1
Sauger	t	t	0	0	t	0.2	t	0.2
Shorthead redhorse	t	t	t	t	0	0	t	t
River herring	0	0	0	0	t	0.1	t	0.1
Longear sunfish	0	0	t	t	0	0	t	t
Golden redhorse	t	t	0	0	0	0	t	t
Quillback	t	t	0	0	0	0	t	t
Brown bullhead	0	0	0	0	t	0.1	t	0.1
White sucker	0	0	0	0	t	0.1	t	0.1
All fish	3,072	32.0	420	29.1	1,324	299.9	4,816	361.0

*Shad considered only as young-of-year and adult

Table 9. SIZE DISTRIBUTION OF MAJOR FISH GROUPS, FORT LOUDOUN RESERVOIR

Fish groups	Percent by number				Percent by weight			
	Young-of-year	Intermediate	Harvestable	Total	Young-of-year	Intermediate	Harvestable	Total
Game	8.6	7.9	2.9	19.4	0.7	6.1	5.8	12.6
Rough	0.7	0.8	1.5	3.0	0.4	2.0	31.9	34.3
Forage	54.5	*	23.1	77.6	7.8	*	45.3	53.1
All fish	63.8	8.7	27.5	100.0	8.9	8.1	83.0	100.0

*Shad considered only as young-of-year and adult

Table 10. AVERAGE GROWTH RATES FOR SOME FORT LOUDOUN FISHES IN 1972 AND 1961

Species	Year	Number	Calculated average total length in mm's-end of year						
			1	2	3	4	5	6	7
Largemouth bass	1972	28	99	236	365				
	1961	6	73	178	259				
White crappie	1972	35	45	151	210	284	311		
	1961	15	58	175	244				
Bluegill	1972	58	47	107	146	182			
	1961	6	48	89	127	152			
Redbreast sunfish	1972	15	56	117	152				
Flathead catfish	1972	15	102	176	255	298			
Channel catfish	1972	38	84	156	244	313	390		

Table 11. PERCENT OF MARKED FISH RECOVERED IN ROTENONE SAMPLES, FORT LOUDOUN RESERVOIR, 1972

Species	Area I		Area II		Area III		Area IV		All		
	Marked	Rec.	Marked	Rec.	Marked	Rec.	Marked	Rec.	Marked	Rec.	% Rec.
Bluegill	37	28	37	26	9	5	-	-	83	59	71.1
Largemouth bass	3	3	4	2	5	1	7	5	19	11	57.9
Smallmouth bass	2	0	1	1	-	-	-	-	3	1	33.3
Other sunfish	-	-	-	-	22	14	59	40	81	54	66.7
White bass	-	-	-	-	-	-	1	0	1	0	0
Crappie	-	-	-	-	-	-	1	1	1	1	100.0
Carp	1	1	5	4	9	7	14	10	29	22	75.9
Shad	10	7	23	7	12	8	23	20	68	42	61.8
Drum	-	-	1	0	1	1	1	1	3	2	66.7
Buffalo	-	-	1	1	3	3	-	-	4	4	100.0
Totals	53	39	72	41	61	39	106	77	292	196	67.1
Percent Rec.		19.9		20.9		19.9		39.3			

TVA Chattanooga 1/19/93

TENNESSEE VALLEY STREAMS:
THEIR FISH, BOTTOM FAUNA, AND AQUATIC HABITAT

THE EMORY RIVER

1968

Division of Forestry, Fisheries, and Wildlife Development
Tennessee Valley Authority
Norris, Tennessee

April 1970

This is the first in a series of reports on a study designed to evaluate the relative abundance (standing crop) and habitat of aquatic life of streams which are tributary to the Tennessee River. The project has a threefold purpose:

> To test and, hopefully, validate methodology for making such evaluations—methodology which will also permit comparisons among streams.
>
> To record present standing crop, provide data from which potential abundance may be predicted, and provide a base from which the impact of future developments (e.g., changing land use practices, mining, sanitation, pollution, dam building, etc.) may be measured.
>
> To develop a "formula" by which other streams may be evaluated without making detailed field surveys such as reported in this series.

Reported here are findings of a study of the Emory River made in August 1968. Similar reports are planned for the Buffalo and Flint Rivers in the Highland Rim, Sequatchie and Powell Rivers in the Great Valley, and the Upper Little Tennessee River in the Blue Ridge province.

THE EMORY RIVER

This survey measured the standing crop of fish and bottom fauna in streams of the Emory River Basin during late summer of 1968.

Description of the Basin

The Emory River drains parts of Cumberland, Morgan, and Roane Counties in east central Tennessee. Total drainage area is 865 square miles. Mean annual streamflow at Oakdale (ERM 18.4) for the past 40 years was 1,406 cfs. Quarterly averages for 1966-68 were 960 cfs for the first quarter, 2,160 for the second, 1,230 for the third, and 535 for the fourth. During the study period of August 19 to September 5, 1968, flow averaged 12 cfs at Oakdale, well below the August 1966 and 1967 average of 364 cfs.

The basin is characterized by rugged topography with narrow streams rapidly descending from the Cumberland Plateau to the Tennessee Valley. Many have cut deep, V-shaped valleys which drop 400 to 600 feet below the surrounding ridges. Pools make up 47 percent of the stream and riffles 53 percent. The average pool is 230 feet long and 50 feet wide, the average riffle 185 feet long and 45 feet wide. Canopy cover over the streams averages 22 percent.

Forest covers about four-fifths of the million-acre watershed, of which approximately 80,000 acres are in the Catoosa Wildlife Management Area. The forest is about 70 percent hardwood and 30 percent pine. Only 10 percent of the basin is devoted to cropland and much of this is either idle or in pasture.

The plateau area of Cumberland and Morgan Counties ranges in elevation from 1,700 to 3,000 feet above mean sea level. Geology of this basin is characterized by relatively flat, alternating beds of shale, limestone, sandstone, and coal of the Pennsylvanian age. Soil in the watershed is of the Ramsey-Porters stony land association, which is most suitable for forest growth, or the Hartsells-Ramsey association, which is only fair for agricultural use. Runoff waters are generally soft, low in dissolved solids, and infertile.

The eastern rim of the basin in Morgan and Roane Counties contains 92 million tons of known recoverable coal reserves. Active mining now occurs largely in the watershed of the upper Emory River proper. Stream disturbance here is primarily from silt. Crab Orchard Creek was receiving acid pollution from stripping operations as recently as 1967. The upper Obed River is polluted periodically from domestic and industrial wastes.

Rainfall over the watershed averages 53 inches annually, 25 of which fall during the growing season (April through September). March is the wettest month, October the driest. Nearly 30 days of drought occur in an average year, usually between August and October. Streamflow varies accordingly from raging torrents following heavy winter and spring rainfall to near cessation of flow during summer and fall drought periods.

Procedures

Emory River and its five major tributary streams (Obed River; Clear, Daddys, Greasy, and Crab Orchard Creeks) were sampled for fish population, bottom fauna and water quality at 16 locations (Figure 1, Table 1). Each sampling location covered approximately one-half mile of the streambed. Dimension of the riffles and pools in the sampling area were derived from aerial photographs. Where aerial photos were unavailable or where photographic features were too small to allow accurate measurements, four on-site transects approximately 880 feet apart were used. Pool and riffle measurements were expanded to one-mile sections to provide a basis for determining the estimated number and weight of fish per stream mile. Physical and chemical characteristics of the various streams are listed in Table 2.

Two one-square-foot Surber bottom samples and one water quality grab sample (temperature, dissolved oxygen, CO_2, pH) were taken at each station. Where available, water quality data from other sources (TVA 1963 revised) were used to supplement the 1968 sample information, and these are summarized in Table 3. Bottom samples were screened through a No. 30 mesh sieve; resultant fauna was preserved in formalin and returned to the Norris Fisheries Laboratory for sorting and identification.

Fish populations were estimated by removing fish from representative stream sections which included a typical riffle and a pool. Each section was defined by block nets and treated with cresol (phenol coefficient of 30) or 5-percent emulsifiable rotenone. Rotenone was applied at not less than 0.6 ppm. and neutralized by potassium permanganate. Both rotenone and cresol were applied by hand. All fish were picked up with dip nets. Easily recognizable ones were sorted by species, counted, weighed, and measured in the field. Others were preserved in a 10-percent formalin solution and returned to the laboratory for measurement and classification. At each sample location scales were taken from small, intermediate, and large specimens of game fish for determination of growth rates.

This inventory provides information on stream fish and bottom fauna populations in the Emory basin during low-flow conditions. Pools and riffles sampled were representative of most of those in the streams, but a few pools too large to sample did exist, so the estimate of fish per stream mile is considered conservative.

Summary of Findings

Average stream population—2,484 fish weighing 43.1 pounds per acre (Table 4). Samples ranged from 0 to 18,360 fish and 0 to 557.2 pounds per mile (Tables 5 and 6).

Distribution of fish—The basin contains a diverse fish population—42 species were collected (Table 7). Six species (rock bass, smallmouth bass, northern hog sucker, stoneroller, warpaint shiner, and greenside darter) were common to all six subdrainages (Tables 5 and 8). Longear sunfish and redline darter were found in five. The average number of species per subdrainage was 21. Emory River had the greatest number (30) of species, while Crab Orchard Creek had the least (12). Nine species were taken at only one of the 16 sampling stations (Table 9).

Estimated population within sampled area—Over 2, 800, 000 fish weighing over 26, 000 pounds (Table 10).

Major fish classes by number—Game 14 percent, rough 14 percent, and forage 76 percent (Table 8).

Major fish classes by weight—Game 41 percent, rough 32 percent, and forage 27 percent (Table 8).

Dominant species by number—Stoneroller 14 percent, whitetail shiner 12 percent, creek chub 9 percent, rock bass 8 percent, and golden redhorse 7 percent (Table 8).

Dominant species by weight—Rock bass 27 percent, northern hog sucker 16 percent, flathead catfish 11 percent, stoneroller 6 percent, and smallmouth bass 6 percent (Table 8).

Growth and size range of fish—Growth rates of Emory basin game fish (Table 11) are slower than those in Watts Bar, its receiving reservoir (TVA,1964). Growth data for the Clinch River basin show rock bass growth to be slower in tributary streams than in the main river (Fitz, 1968).

Food Conditions—Forage fish were numerous, comprising nearly three-fourths of the total basin population. Bottom fauna standing crop was greatest in Daddys and Clear Creek basins and least in areas influenced by mining activities or industrial pollution—lower Emory River, lower Crab Orchard Creek, and the upper Obed River (Table 12). Mayflies and true midges were the predominant bottom organisms.

Per-acre production—The average standing crop of fish was 43.1 pounds per acre, invertebrates 34.2 pounds. Fish production was highest in Greasy Creek, upper Crab Orchard, and lower Obed River and lowest in those stream sections where bottom fauna production was also poor.

General Conclusions

The 1968 survey of the Emory River shows the basin contains a diverse fish population of 42 species. In terms of standing crop it is composed generally of the rock bass-smallmouth bass-hog sucker community; in terms of numerical abundance, minnows and other forage fish dominate (72 percent).

Game fish comprised 14 percent of the total population sample by number but 41 percent of the weight,primarily because of the large rock bass population. Compared with its tributary streams the main Emory River has a sparse population of game fish.

Fish abundance (standing crop) varied considerably between sample stations in the same subdrainage as well as between subdrainage areas. No chemically toxic conditions were found, but species distribution suggests that degraded stream conditions from mining or industrial activity is limiting both the variety and total number of fish in some sections of the Obed and Emory Rivers. Further, no fish were found in lower Crab Orchard Creek which runs through an abandoned strip mine below the sample station. Water temperature here was 10 to 20° F. higher than at other stations and the stream bottom was predominantly bedrock and boulders. High sulphate measurements in both the lower Emory River and Crab Orchard Creek are indicative of mine drainage.

Samples of bottom food organisms were insufficient to determine distribution patterns; however, those tributaries which drain watersheds least disturbed by man (Clear and Daddys Creeks) had the greatest variety and density of organisms.

Literature Cited

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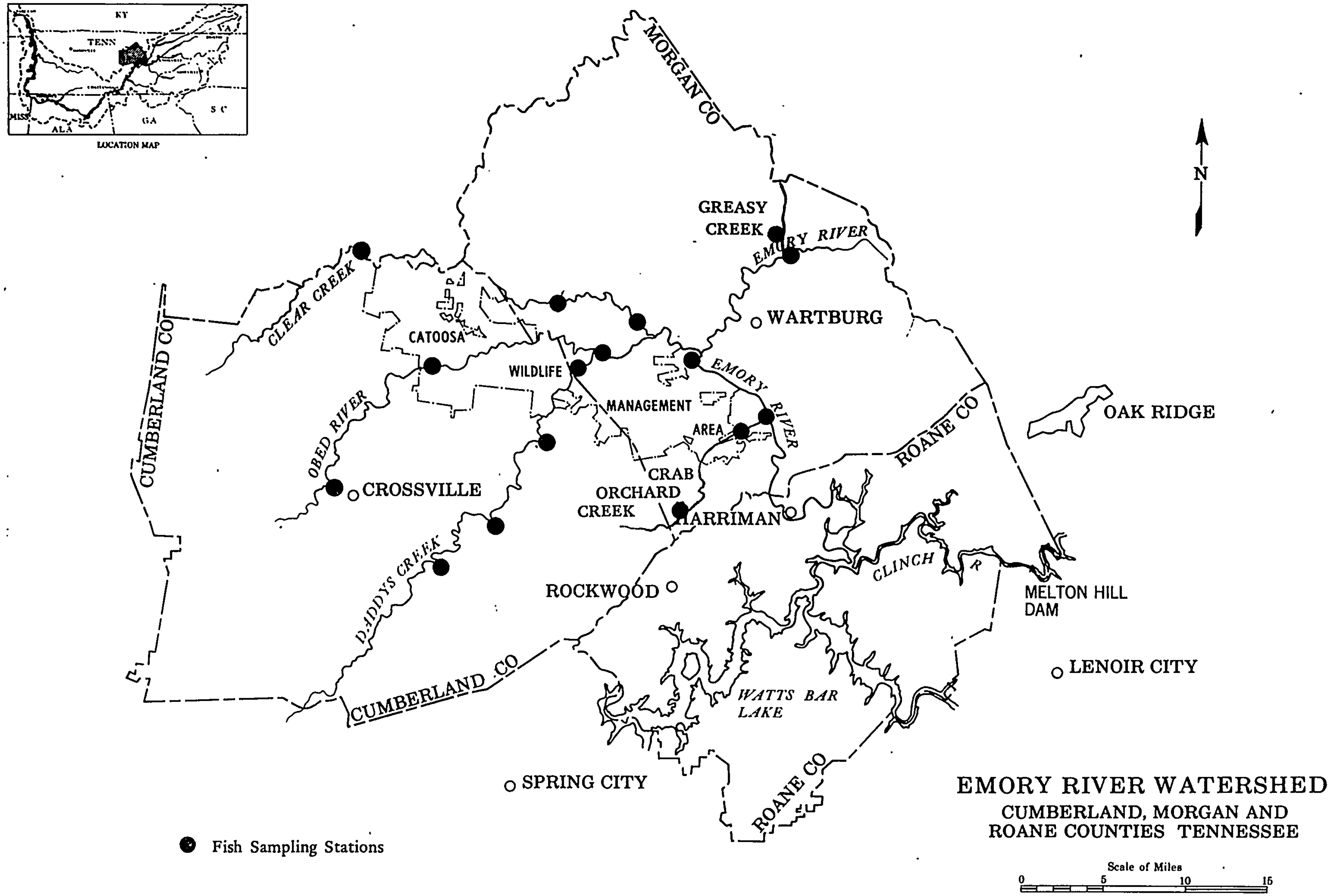


Figure 1. Sampling stations in the Emory River drainage, August 1968.

Table 1. Fish sampling stations, Emory River Basin, August 1968

Emory River

Mile 21, just below Camp Austin Bridge
Mile 28, just above Nemo Bridge between Wartburg and Catoosa, Tennessee
Mile 40.8, just below bridge, 1.5 miles east of Gobey, Tennessee

Greasy Creek

Mile 0.3, just below bridge on County Road 2394 north of Gobey, Tennessee

Crab Orchard Creek

Mile 2.5, just above bridge near White Oak Church
Mile 10.8, just above bridge approximately 0.25 mile below the Morgan and Cumberland County line

Clear Creek

Mile 1.2, just below Lilly Bridge
Mile 8.8, above Wattman Ford Bridge and 300 feet below mouth of White Creek
Mile 29, just below Highway 127 Bridge

Obed River

Mile 10, approximately 400 feet below mouth of Daddys Creek
Mile 24.5, half mile below bridge on County Road 4252
Mile 40, just above Highway 70S Bridge in Crossville, Tennessee

Daddys Creek

Mile 2.3, just below bridge at Devil's Breakfast Table in Catoosa Wildlife Area
Mile 9.1, just above Antioch Bridge near Watson, Tennessee
Mile 17.2, just below Center Bridge north of Crab Orchard, Tennessee
Mile 26, just below Highway 68 Bridge

Table 2. Physical and chemical characteristics of sample stations in the Emory River Basin, August 1968

Stream characteristic	Station: Emory River Mile 21	Emory River Mile 28	Emory River Mile 40.8	Greasy Creek Mile 0.3	Crab Orchard Creek Mile 2.5	Crab Orchard Creek Mile 10.8	Clear Creek Mile 1.2	Clear Creek Mile 8.8	Clear Creek Mile 29	Obed River Mile 10	Obed River Mile 24.5	Obed River Mile 40	Daddys Creek Mile 2.3	Daddys Creek Mile 9.1	Daddys Creek Mile 17.2	Daddys Creek Mile 26
Water flow 1/	C	C	C	P	C	P	C	C	C	C	C	C	C	C	C	C
Avg. velocity 2/	S	S	S	S	R	S	S	S	S	S	S	R	S	S	S	R
Percent stream in pools	70	55	26	32	40	39	62	72	41	44	40	42	45	43	46	48
Percent stream in riffle	30	45	74	68	60	61	38	28	59	56	60	58	55	57	54	52
Avg. riffle length (ft.)	270	172	163	115	123	115	185	226	151	246	128	153	266	251	273	140
Avg. riffle width (ft.)	104	49	14	20	32	11	69	55	30	85	30	9	49	53	53	27
Avg. pool length (ft.)	627	194	62	58	87	74	279	313	157	280	217	123	327	342	363	161
Avg. pool width (ft.)	133	49	34	23	43	37	102	75	33	73	23	18	47	49	51	24
Avg. riffle depth (ft.)	0.9	0.3	0.6	0.2	0.3	0.2	0.2	0.3	0.1	0.6	0.5	0.2	0.6	0.3	0.6	0.6
Avg. pool depth (ft.)	2.3	1.5	1.2	0.7	1.0	0.8	1.8	2.5	0.8	2.0	1.6	0.9	1.4	1.2	1.2	1.3
Percent canopy cover (shade)	0	2	69	75	5	25	1	8	14	5	41	50	1	18	6	25
Length (ft.) of sampling area	100	220	112	105	110	130	250	200	125	220	156	120	200	235	143	200
Estimated percent composition of riffle bottom																
Mud	-	-	12.5	-	-	-	-	5	-	-	2.5	15	-	-	-	-
Silt	5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Sand	2.5	-	12.5	2.5	-	6.6	2	20	10	-	7.5	-	-	-	5	5
Clay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gravel	2.5	5	25	2.5	-	8.3	-	25	30	5	7.5	15	15	-	7.5	7.5
Rubble	10	10	25	22.5	10	8.3	15	20	20	30	22.5	60	32.5	-	10	12.5
Boulders	35	85	5	70	45	46.6	15	30	40	65	6.0	10	52.5	2.5	75	75
Bedrock	45	-	15	2.5	45	30	68	-	-	-	-	-	-	97.5	2.5	-
Estimated percent composition of pool bottom																
Mud	-	-	35	55	-	-	-	1.6	6.6	-	5	35	-	-	7.5	10
Silt	12.5	-	25	10	-	-	-	-	11.6	-	7.5	20	-	-	2.5	-
Sand	12.5	5	10	10	3.3	15	7.5	3.3	11.6	12.5	7.5	10	-	-	7.5	5
Clay	-	-	-	5	-	-	-	-	-	-	-	5	-	-	10	-
Gravel	-	8.9	5	7.5	-	10	5	5	15	10	10	10	7.5	5	7.5	5
Rubble	20	8.9	15	2.5	8.3	5	5	15	18.3	27.5	15	20	12.5	5	35	20
Boulders	55	45	-	-	13.3	10	5	43.3	36.6	55	52.5	-	75	5	40	30
Bedrock	-	36	10	10	75	60	77.5	31.6	-	-	-	-	5	85	-	30
Temperature (°F)	72	80	79	74	87	77	72	78	64	75	66	75	81	70	65	66
Dissolved oxygen (mg/l)	8.7	7.9	7.4	7.2	7.8	8.1	8.1	7.8	7.6	7.9	7.2	7.2	8.2	7.6	7.8	8.3
Alkalinity (mg/l) 3/	27	23	18	21	8	9	14	16	12	12	17	14	21	17	14	17
pH	6.9	7.2	6.4	7.8	6.9	7.4	7.6	7.3	6.5	7.2	7.1	6.9	7.4	7.2	7.3	7.5
Free CO_2 (mg/l)	4.2	1.3	2.7	3.4	2.3	1.2	1.4	3.6	6.7	2.4	2.9	4.2	1.3	2.9	-	3.2

1/ C = continuous, P = in pools only.
2/ S = sluggish (< 1/2'/sec.), R = rapid (> 1/2'/sec.).
3/ Total alkalinity as $CaCO_3$.

Table 3. Water quality of the surface waters in the Emory River Drainage Basin (mineral analyses in parts per million)

Year of Collection	Number of samples	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids (residue of 180°C)	Hardness as $CaCO_3$ Calcium Magnesium	Hardness as $CaCO_3$ Non-carbonate	Specific conductivity (micromhos at 25° C.)	pH	Color
EMORY RIVER NEAR SUGAR GROVE, TENNESSEE, MILE 3.9																		
700 feet below Kings Creek, drainage area 855 square miles. Analyses by State of Tennessee.																		
1960	5	4.9	0.50	6.9	2.6	1.3	0.4	25	9.0	5.0	0.0	0.70	32	28	-	-	7.1	31.0
EMORY RIVER AT HARRIMAN, TENNESSEE, MILE 10.7																		
At No. 1 sewage pump station. Analyses by State of Tennessee.																		
1960	5	5.6	0.30	2.5	1.0	1.0	0.5	9	8.0	3.0	0.0	0.40	41	10	-	-	6.8	16.0
EMORY RIVER AT OAKDALE, TENNESSEE, MILE 18.4																		
At county road bridge, drainage area 764 square miles. Analyses by State of Tennessee, TVA, USGS.																		
1960	5	5.2	0.40	1.9	1.6	1.0	0.5	13	7.0	2.0	0.0	0.50	60[a]	12	-	-	6.9	16.0
1965	2	3.1	0.02	6.0	1.3	1.3	0.7	19	14.0	1.8	0.0	0.00	38	24	10	69	7.1	6.0
1966	4	2.4	0.00	7.0	1.2	1.7	2.2	14	13.2	2.9	-	0.20	48	22	-	62	6.8	4.0
1967	8	3.6	0.02	5.2	1.0	1.3	1.0	10	10.2	1.9	0.0	0.30	28	17	-	52	6.6	7.1
EMORY RIVER NEAR WARTBURG, TENNESSEE, MILE 35.3																		
Midstream 300 feet below bridge on Highway 62. Analyses by TVA and USGS.																		
1964*	1	4.5	0.00	10.0	2.4	1.7	2.7	19	24.8	1.5	-	0.00	55	36	-	94	6.8	3.0
1965	1	-	0.10	-	-	-	-	15	8.6	0.8	-	0.10	-	17	5	48	6.9	4.0
1966	6	4.7	0.00	8.8	2.0	1.5	2.4	19	17.7	1.5	-	0.20	55	30	-	80	6.9	5.0
1967	9	4.3	0.00	5.7	1.4	1.5	1.2	13	11.4	1.7	-	0.30	37	20	-	56	6.8	7.0
1968	4	3.7	0.06	7.1	0.5	1.3	1.2	14	9.4	1.6	-	0.10	33	19	-	53	6.5	5.0
EMORY RIVER NEAR MACEDONIA CHURCH, TENNESSEE, MILE 45.5. Analyses by TVA.																		
1966	1	5.0	0.00	17.0	6.3	2.5	2.7	20	57.0	1.5	-	0.30	111	69	-	170	7.2	3.0
1967	3	5.4	0.08	9.8	2.7	2.0	1.5	18	25.5	1.2	-	0.10	52	36	-	94	7.0	5.0
1968	5	4.3	0.12	18.6	5.7	1.6	1.8	10	62.2	1.3	-	0.20	109	59	-	156	6.6	7.0
CRAB ORCHARD CREEK NEAR DEERMONT, TENNESSEE, MILE 0.5. Analyses by TVA.																		
1966	6	4.1	0.00	9.1	5.2	0.8	2.2	2	43.8	2.2	-	0.02	76	44	-	118	4.8	3.0
1967	10	3.8	0.00	4.5	2.8	0.8	1.0	2	22.0	1.3	-	0.09	40	23	-	72	5.1	3.0
1968	4	4.0	0.04	7.2	4.2	0.8	1.1	1	34.8	1.5	-	0.08	61	34	-	91	4.7	4.5
GREASY CREEK ABOVE MIKE HOLLOW NEAR GOBEY, TENNESSEE, APPROXIMATELY MILE 3. Analyses by TVA.																		
1966	1	5.7	0.00	3.3	0.4	1.5	1.5	10	4.8	1.5	-	0.0	24	10	-	35	6.5	3.0
1967	3	6.0	0.03	3.0	0.6	1.4	1.1	12	3.0	1.2	-	0.1	19	10	-	31	6.7	4.0
1968	4	5.2	0.06	3.2	0.9	1.2	0.9	8	5.5	1.0	0.00	0.0	10	9	-	28	6.6	5.0
OBED RIVER AT ALLEY FORD BRIDGE NEAR LANCING, TENNESSEE, MILE 1.4. Analyses by TVA and USGS.																		
1964	1	2.6	0.00	5.7	1.2	1.1	0.8	18	7.2	1.1	0.00	0.0	21	19	4	51	7.2	3.0
1965	5	2.2	0.00	4.4	0.8	1.4	1.6	17	3.7	2.2	0.05	0.2	27	15	2	41	6.7	5.0
1966	9	2.5	0.00	4.1	0.6	0.9	1.6	11	3.5	2.2	-	0.2	23	12	-	33	6.7	5.0
1967	8	2.5	0.02	3.6	0.4	1.0	0.9	9	3.1	2.1	0.00	0.3	19	10	-	32	6.8	4.8
1968	3	2.7	0.03	3.2	0.3	0.9	1.1	7	4.5	1.7	0.00	0.4	23	9	-	27	6.5	6.7
OBED RIVER 0.1 MILE BELOW DADDYS CREEK																		
From left bank at old bridge pier. Analyses by TVA and USGS.																		
1965	1	-	0.10	-	-	-	-	18	2.6	1.3	-	0.2	-	15	0	40	7.0	6.0
1966	1	2.9	0.00	3.9	0.4	1.1	1.3	9	3.6	2.5	-	0.4	29	11	-	35	6.9	5.0
1967	3	1.1	0.04	5.5	0.6	1.3	1.1	17	2.3	2.7	-	0.1	28	16	-	43	7.0	5.0
1968	5	1.6	0.06	6.1	0.3	2.2	1.6	15	3.2	5.0	-	0.5	37	16	-	52	6.8	5.0
DADDYS CREEK NEAR HERBERTSBURG, TENNESSEE																		
From gaging station on left bank, upstream of bridge. Analyses by TVA and USGS.																		
1963	11	1.8	0.00	6.6	1.3	1.2	1.6	23	3.4	1.7	-	0.1	32	21	-	56	7.2	5.0
1965	2	3.2	0.06	5.3	-	-	-	24	4.7	1.5	-	0.2	-	20	1	51	7.3	8.0
1966*	1	3.1	0.00	3.9	0.6	0.8	1.0	8	5.0	2.0	-	1.1	27	12	5	31	6.8	5.0

* Source of data not located.
a. Evaporation temperature of 103° C.

Table 4. Per-acre production* of fish and invertebrates, Emory River Basin, 1968

Station	Fish		Invertebrates	
	Number	Weight (pounds)	Number (x 1,000)	Weight (pounds)
Emory River Mile 21	1,578	31.3	304	0.9
Emory River Mile 28	1,412	6.6	174	4.5
Emory River Mile 40.8	1,604	13.4	566	1.4
Greasy Creek Mile 0.3	4,170	111.8	523	2.2
Crab Orchard Creek Mile 2.5	0	0	348	0.8
Crab Orchard Creek Mile 10.8	3,287	122.8	1,873	33.5
Clear Creek Mile 1.2	586	14.1	2,526	23.6
Clear Creek Mile 8.8	1,340	21.4	479	44.6
Clear Creek Mile 29	6,693	45.0	871	3.3
Obed River Mile 10	3,234	157.5	1,307	3.8
Obed River Mile 24.5	5,696	25.8	1,437	36.5
Obed River Mile 40	887	3.3	87	0.5
Daddys Creek Mile 2.3	962	9.3	3,223	14.5
Daddys Creek Mile 9.1	820	36.1	1,677	12.5
Daddys Creek Mile 17.2	4,240	70.9	2,178	8.4
Daddys Creek Mile 26	3,235	20.4	1,873	355.6
Average all samples (per acre)	2,484	43.1	1,215	34.2
Number and kilograms/hectare	6,135	48.3	3,001	38.4

*Based on actual size of sampled area.

Table 5. Distribution by number of fish per stream mile at various stations in the Emory River Drainage Basin, August 1968

Species	Station: Emory River Mile 21	Emory River Mile 28	Emory River Mile 40.8	Greasy Creek Mile 0.3	Crab Orchard Creek Mile 2.5	Crab Orchard Creek Mile 10.8	Clear Creek Mile 1.2	Clear Creek Mile 8.8	Clear Creek Mile 29	Obed River Mile 10	Obed River Mile 24.5	Obed River Mile 40	Daddys Creek Mile 2.3	Daddys Creek Mile 9.1	Daddys Creek Mile 17.2	Daddys Creek Mile 26	Total
Game Fish					NO FISH												
Muskellunge	-	-	-	-		-	-	10	-	-	-	-	-	-	-	-	10
Warmouth	-	-	-	-		-	-	-	-	-	30	-	-	-	-	18	48
Rock bass	30	27	23	1,159		1,680	332	402	918	900	1,320	-	89	676	523	579	8,648
Redbreast sunfish	-	-	-	-		-	69	-	-	830	-	-	-	365	282	-	1,546
Green sunfish	-	-	-	-		-	-	-	34	-	15	-	-	36	25	140	250
Bluegill sunfish	-	-	-	-		140	-	39	-	20	270	-	-	45	-	88	602
Longear sunfish	24	-	-	-		504	-	118	493	180	330	-	-	-	66	-	1,715
Smallmouth bass	36	302	69	31		364	104	274	-	750	150	-	107	151	50	140	2,528
Spotted bass	-	-	23	122		-	-	-	-	-	-	-	-	-	-	-	145
Largemouth bass	-	-	-	-		-	-	10	17	-	-	-	-	-	42	53	122
Rough Fish																	
White sucker	-	-	-	-		476	-	-	-	-	-	19	-	-	-	-	495
Northern hog sucker	48	115	138	213		364	58	304	833	60	720	-	27	80	506	474	3,940
Black redhorse	-	-	-	549		-	-	-	-	-	-	-	-	-	-	-	549
Golden redhorse	-	27	667	-		-	-	-	-	-	6,540	-	-	-	963	-	8,197
Black bullhead	-	-	-	-		-	-	147	17	-	285	-	-	-	-	-	449
Yellow bullhead	-	-	92	-		-	-	-	-	-	-	-	-	-	-	-	92
Channel catfish	114	42	-	-		-	-	-	-	-	-	-	-	-	-	-	156
Flathead catfish	138	14	-	-		-	69	-	-	1,310	-	-	18	53	-	-	1,602
Forage Fish																	
Stoneroller	-	1,469	184	1,372		448	-	235	1,632	1,080	5,985	-	303	18	2,988	105	15,819
River chub	18	388	-	-		-	115	804	-	1,030	150	-	142	328	398	421	3,794
Popeye siner	-	-	874	671		-	-	1,254	-	250	255	-	-	-	-	-	3,304
Warpaint shiner	-	964	-	396		224	-	274	-	140	-	-	1,086	383	739	1,824	6,030
Common shiner	-	-	-	4,697		-	-	-	-	-	-	-	-	-	-	-	4,697
Whitetail shiner	138	1,051	-	-		-	69	1,450	-	3,990	1,185	-	-	409	365	4,771	13,428
Tennessee shiner	-	3,108	-	-		-	-	-	-	-	-	-	-	-	-	-	3,108
Silver shiner	162	1,548	-	-		-	-	-	-	-	-	-	-	-	-	-	1,746
Mimic shiner	-	3,024	-	-		-	-	-	-	-	-	-	-	-	-	-	3,024
Steelcolor shiner	-	-	-	-		5,824	-	-	34	-	645	-	383	-	-	-	6,886
Suckermouth minnow	24	677	-	-		-	-	176	-	-	-	-	-	-	-	-	877
Creek chub	-	-	437	1,677		28	-	20	7,123	-	-	342	-	-	-	-	9,627
Greenside darter	12	432	-	122		56	288	108	-	160	90	-	80	134	50	70	1,602
Blueside darter	12	-	-	-		-	-	-	-	-	-	-	-	-	-	-	12
Stripetail darter	60	-	230	366		56	12	-	-	-	-	-	-	-	-	-	724
Spotted darter	-	-	-	-		-	-	-	-	120	-	-	27	-	-	-	147
Redline darter	102	1,051	69	213		-	58	755	-	560	285	-	276	18	166	-	3,553
Tennessee sunbnose darter	114	-	-	-		-	-	-	-	-	-	-	-	-	-	438	552
Banded darter	-	43	-	-		-	-	-	-	-	-	-	-	-	-	-	43
Yellow darter	222	749	-	-		-	575	196	-	200	15	-	98	214	116	-	2,385
Logperch	78	27	230	152		-	-	-	-	-	-	-	-	-	-	-	487
Gilt darter	66	27	-	-		-	-	-	-	-	-	-	-	-	-	-	93
Olive darter	138	173	-	-		-	12	59	-	250	90	-	-	45	-	-	767
Brook silversides	264	-	-	-		-	-	-	-	-	-	-	-	-	-	-	264
Total	1,800	15,294	3,036	11,740		10,164	1,751	6,635	11,101	11,830	18,360	361	2,636	2,955	7,279	9,121	114,063

Table 6. Distribution by weight (pounds per stream mile) of fish at various stations in the Emory River Drainage Basin, August 1968

Species	Station																Total
	Emory River Mile 21	Emory River Mile 28	Emory River Mile 40.8	Greasy Creek Mile 0.3	Crab Orchard Creek Mile 2.5	Crab Orchard Creek Mile 10.8	Clear Creek Mile 1.2	Clear Creek Mile 8.8	Clear Creek Mile 29	Obed River Mile 10	Obed River Mile 24.5	Obed River Mile 40	Daddys Creek Mile 2.3	Daddys Creek Mile 9.1	Daddys Creek Mile 17.2	Daddys Creek Mile 26	
Game Fish																	
Muskellunge	-	-	-	-		-	-	0.1	-	-	-	-	-	-	-	-	0.1
Warmouth	-	-	-	-		-	-	-	-	-	2.3	-	-	-	-	2.8	5.1
Rock bass	4.8	2.7	3.8	207.4		176.4	5.2	15.7	12.4	35.7	6.9	-	5.1	50.0	14.4	8.8	549.3
Redbreast sunfish	-	-	-	-		-	1.1	-	-	74.0	-	-	-	15.1	6.7	-	96.9
Green sunfish	-	-	-	-		-	-	-	1.7	-	0.4	-	-	1.8	1.5	11.1	16.5
Bluegill sunfish	-	-	-	-		3.5	-	2.1	-	Tr.	0.2	-	-	7.8	-	12.2	25.8
Longear sunfish	1.8	-	-	-		14.6	-	5.9	1.5	0.4	2.3	-	-	-	1.5	-	28.0
Smallmouth bass	1.2	7.0	0.1	2.9		19.4	1.2	7.8	-	70.0	5.1	-	2.7	6.5	1.0	3.6	128.5
Spotted bass	-	-	6.5	0.5		-	-	-	-	-	-	-	-	-	-	-	7.0
Largemouth bass	-	-	-	-		-	-	0.5	0.1	-	-	-	-	-	4.6	0.2	5.4
Rough Fish																	
White sucker	-	-	-	-		75.0	-	-	-	-	-	0.5	-	-	-	-	75.5
Northern hog sucker	19.8	5.4	6.9	21.6		51.2	15.3	41.4	7.9	69.0	3.8	-	0.2	15.2	63.7	2.1	323.5
Black redhorse	-	-	-	4.7		-	-	-	-	-	-	-	-	-	-	-	4.7
Golden redhorse	-	0.1	2.3	-		-	-	-	-	-	17.4	-	-	-	2.7	-	22.5
Yellow bullhead	-	-	0.5	-		-	-	-	-	-	-	-	-	-	-	-	0.5
Black bullhead	-	-	-	-		-	-	0.9	0.1	-	1.0	-	-	-	-	-	2.0
Channel catfish	0.4	0.3	-	-		-	-	-	-	-	-	-	-	-	-	-	0.7
Flathead catfish	3.6	0.2	-	-		-	12.6	-	-	196.9	-	-	2.5	16.1	-	-	231.9
Forage Fish					FISH												
Stoneroller	-	7.8	0.2	8.7		2.5	-	1.0	10.3	48.0	26.0	-	6.5	0.3	18.5	0.3	130.1
River chub	0.1	5.0	-	-		-	0.7	8.0	-	41.9	0.7	-	3.1	6.7	2.4	0.9	69.5
Popeye shiner	-	-	0.9	1.7		-	-	3.4	-	0.4	1.3	-	-	-	-	-	7.7
Warpaint shiner	-	2.2	-	1.2		3.1	-	1.3	-	0.2	-	-	2.2	2.2	1.7	3.1	17.2
Common shiner	-	-	-	40.7		-	-	-	-	-	-	-	-	-	-	-	40.7
Whitetail shiner	1.8	7.7	-	-		-	8.7	9.0	-	4.5	14.3	-	-	2.9	0.6	19.2	68.7
Tennessee shiner	-	4.2	-	-		-	-	-	-	-	-	-	-	-	-	-	4.2
Silver shiner	0.5	12.5	-	-		-	-	-	-	-	-	-	-	-	-	-	13.0
Mimic shiner	-	6.4	-	-	NO	-	-	-	-	-	-	-	-	-	-	-	6.4
Steelcolor shiner	-	-	-	-		29.0	-	-	Tr.	-	1.4	-	0.2	-	-	-	30.6
Suckermouth minnow	0.1	2.2	-	-		-	-	0.7	-	-	-	-	-	-	-	-	3.0
Creek chub	-	-	0.5	19.0		3.1	-	0.1	40.6	-	-	0.8	-	-	-	-	64.1
Greenside darter	0.6	2.3	-	1.6		0.1	0.8	1.1	-	0.9	0.9	-	0.5	1.0	0.1	1.0	10.9
Blueside darter	0.1	-	-	-		-	-	-	-	-	-	-	-	-	-	-	0.1
Stripetail darter	0.1	-	0.2	1.3		0.1	0.1	-	-	-	-	-	-	-	-	-	1.8
Spotted darter	-	-	-	-		-	-	-	-	1.5	-	-	0.1	-	-	-	1.6
Redline darter	0.2	2.3	0.2	1.3		-	0.2	2.4	-	2.5	0.2	-	0.9	0.1	0.5	-	10.8
Tennessee snubnose darter	0.2	-	-	-		-	-	-	-	-	-	-	-	-	-	0.5	0.7
Banded darter	-	0.1	-	-		-	-	-	-	-	-	-	-	-	-	-	0.1
Yellow darter	1.2	14.1	-	-		-	9.6	3.5	-	7.5	Tr.	-	1.4	3.8	1.7	-	42.8
Logperch	1.2	0.8	0.9	1.5		-	-	-	-	-	-	-	-	-	-	-	4.4
Gilt darter	0.1	0.1	-	-		-	-	-	-	-	-	-	-	-	-	-	0.2
Olive darter	0.2	0.3	-	-		-	0.3	1.0	-	3.8	0.2	-	-	0.9	-	-	6.7
Brook silversides	0.1	-	-	-		-	-	-	-	-	-	-	-	-	-	-	0.1
Total	38.1	83.7	23.0	314.1		378.0	55.8	105.9	74.6	557.2	84.4	1.3	25.4	130.4	121.6	65.8	2,059.3

Table 7. Common and scientific names* of fishes in rotenone samples from Emory River Drainage Basin, 1968

Game Fish	
Muskellunge	Esox masquinongy
Warmouth	Chaenobryttus gulosus
Rock bass	Ambloplites rupestris
Redbreast sunfish	Lepomis auritus
Green sunfish	Lepomis cyanellus
Bluegill sunfish	Lepomis macrochirus
Longear sunfish	Lepomis megalotis
Smallmouth bass	Micropterus dolomieui
Spotted bass	Micropterus punctulatus
Largemouth bass	Micropterus salmoides
Rough Fish	
White sucker	Catostomus commersoni
Northern hog sucker	Hypentelium nigricans
Black redhorse	Moxostoma duquesnei
Golden redhorse	Moxostoma erythrurum
Black bullhead	Ictalurus melas
Yellow bullhead	Ictalurus natalis
Channel catfish	Ictalurus punctatus
Flathead catfish	Pylodictis olivaris
Forage Fish	
Stoneroller	Campostoma anomalum
River chub	Hybopsis micropogon
Popeye shiner	Notropis ariommus
Warpaint shiner	Notropis coccogenis
Common shiner	Notropis cornutus
Whitetail shiner	Notropis galacturus
Tennessee shiner	Notropis leuciodus
Silver shiner	Notropis photogenis
Mimic shiner	Notropis volucellus
Steelcolor shiner	Notropis whipplei
Suckermouth minnow	Phenacobius mirabilis
Creek chub	Semotilus atromaculatus
Greensider darter	Etheostoma blennioides
Blueside darter	Etheostoma jessiae
Striptail darter	Etheostoma kennicotti
Spotted darter	Etheostoma maculatum
Redline darter	Etheostoma rufilineatum
Tennessee snubnose darter	Etheostoma simoterum
Banded darter	Etheostoma zonale
Yellow darter	Percina aurantiaca
Logperch	Percina caprodes
Gilt darter	Percina evides
Olive darter	Percina squamata
Brook silversides	Labidesthes sicculus

*According to American Fisheries Society Special Publication No. 2, 1960.

Table 8. Species composition and frequency of occurrence in 16 samples, Emory River Basin, August 1968

Species	Percent		
	Total number	Total weight	Frequency occurrence
Stoneroller	13.9	6.3	75.00
Whitetail shiner	11.8	3.3	56.25
Creek chub	8.5	3.1	37.50
Rock bass	7.6	26.7	87.50
Golden redhorse	7.2	1.1	25.00
Steelcolor shiner	6.1	1.5	31.25
Warpaint shiner	5.3	0.8	56.25
Common shiner	4.1	2.0	6.25
Northern hog sucker	3.5	15.7	87.50
Redline darter	3.1	0.5	68.75
Popeye shiner	2.9	0.4	31.25
River chub	3.3	3.4	62.50
Tennessee shiner	2.7	0.2	6.25
Mimic shiner	2.7	0.3	6.25
Smallmouth bass	2.2	6.2	81.25
Yellow darter	2.1	2.1	56.25
Silver shiner	1.5	0.6	12.50
Longear sunfish	1.5	1.4	43.75
Flathead catfish	1.4	11.3	37.50
Redbreast sunfish	1.4	4.7	25.00
Greensider darter	1.4	0.5	75.00
Suckermouth minnow	0.8	0.2	18.75
Olive darter	0.7	0.3	43.75
Stripetail darter	0.6	0.1	31.25
Black redhorse	0.5	0.2	6.25
Bluegill sunfish	0.5	1.3	37.50
Tennessee snubnose darter	0.5	T	12.50
Black bullhead	0.4	0.1	18.75
Logperch	0.4	0.2	25.00
White sucker	0.4	3.7	12.50
Brook silversides	0.2	T	6.25
Green sunfish	0.2	0.8	31.25
Channel catfish	0.1	T	12.50
Gilt darter	0.1	T	12.50
Spotted darter	0.1	0.1	12.50
Largemouth bass	0.1	0.3	25.00
Spotted bass	0.1	0.3	12.50
Yellow bullhead	0.1	T	6.25
Warmouth	T	0.3	12.50
Muskellunge	T	T	6.25
Banded darter	T	T	6.25
Blueside darter	T	T	6.25

T = less than 0.05.

Table 9. Fish populations by major fish groups in subdrainages, Emory River Basin, August 1968

Subdrainage area	Fish group	Number of species	Average number per stream mile	Average weight (lbs.) per stream mile
Emory River	Game	4	178	9.3
3 samples	Rough	5	465	13.2
	Forage	21	6,067	25.8
			6,710	48.3
Greasy Creek	Game	3	1,312	210.8
1 sample	Rough	2	762	26.3
	Forage	9	9,666	77.0
			11,740	314.1
Crab Orchard Creek	Game	4	1,344	107.0
2 samples	Rough	2	420	63.1
	Forage	6	3,318	18.9
			5,082	189.0
Clear Creek	Game	8	937	18.4
3 samples	Rough	3	476	26.0
	Forage	13	5,083	34.3
			6,496	78.7
Obed River	Game	7	1,598	65.8
3 samples	Rough	5	2,978	96.2
	Forage	12	5,608	52.3
			10,184	214.3
Daddys Creek	Game	8	869	39.4
4 samples	Rough	3	530	25.6
	Forage	11	4,099	20.8
			5,498	85.8
All areas	Game	10	976	53.9
16 samples	Rough	8	968	41.3
	Forage	24	5,185	33.5
		42	7,129	128.7

Table 10. Estimated total population within sampled area

Drainage	Acres*	Fish		Invertebrates	
		Number	Weight (pounds)	Number (x 1000)	Weight (pounds)
Emory River	215.8	330,390	3,690.2	750,984	496.3
Greasy Creek	0.8	3,336	89.4	453	17.8
Crab Orchard Creek	29.4	48,334	1,805.2	31,634	505.7
Clear Creek	223.2	641,254	6,001.8	288,374	5,312.2
Obed River	170.5	557,876	10,605.1	160,952	2,318.8
Daddys Creek	134.1	1,241,364	4,586.2	300,116	13,115.0
Total	773.8	2,822,554	26,777.9	1,532,513	21,765.8

*Based on average width of stream within the sampling area.

Table 11. Average growth rates of various game fishes, Emory River Basin, 1968

Species	Year class represented	Number of fish	Calculated average total length in inches at end year					
			1	2	3	4	5	6
Largemouth bass	1964-65	4	2.1	4.9	6.4	8.0	-	-
Smallmouth bass	1963-64-65-66-67	25	2.7	4.4	6.4	8.3	-	-
Rock bass	1963-64-65-66-67	59	1.5	2.9	4.2	5.4	6.5	6.9
Bluegill sunfish	1964-65-66-67	18	1.2	2.6	4.1	5.3	-	-
Redbreast sunfish	1963-64-65-66	18	1.8	3.6	4.9	5.4	7.2	-
Longear sunfish	1963-64-65-67	17	1.4	2.6	3.5	3.9	4.0	-
Green sunfish	1964-65-66-67	16	1.5	2.7	3.5	4.7	-	-

Table 12. Numbers of bottom organisms per square meter and their combined total weight at various stations in the Emory River basin, August 1968

Species	Station															
	Emory River Mile 21	Emory River Mile 28	Emory River Mile 40.8	Greasy Creek Mile 0.3	Crab Orchard Creek Mile 2.5	Crab Orchard Creek Mile 10.8	Clear Creek Mile 1.2	Clear Creek Mile 8.8	Clear Creek Mile 29	Obed River Mile 10	Obed River Mile 24.5	Obed River Mile 40	Daddys Creek Mile 2.3	Daddys Creek Mile 9.1	Daddys Creek Mile 17.2	Daddys Creek Mile 26
Mollusca																
Pelecypoda (mussels)	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-
Gastropoda (snails)	-	-	-	-	-	-	-	11	-	-	-	-	-	75	32	-
Crustacean																
Amphipoda	-	-	-	-	-	11	-	-	-	-	-	-	-	5	-	-
Decapoda (crayfish)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
Odonata																
Coenagrionidae (damsel fly)	-	-	-	-	-	-	21	-	-	11	-	-	43	11	32	-
Aeschnidae (dragon fly)	-	-	-	-	-	-	11	-	-	-	-	-	43	32	11	11
Plecoptera																
Nemouridae (stonefly)	-	-	-	-	75	-	-	-	-	-	-	-	-	22	-	-
Ephemeroptera (mayflies)																
Ephemeridae	-	-	-	32	-	32	11	-	-	-	-	-	-	43	-	-
Heptageniidae	11	-	65	-	-	129	108	11	97	27	75	-	387	118	344	43
Baetidae	32	-	22	-	-	32	75	43	54	-	-	-	54	76	-	-
Coleoptera (beetles)																
Psephenidae	-	11	-	-	-	-	11	-	-	-	-	-	-	-	11	-
Neuroptera																
Sialidae (dobsonfly or helgramites)	-	11	-	-	-	-	-	21	32	-	-	-	-	-	86	43
Trichoptera																
Hydropsychidae (caddisfly)	21	-	-	11	11	22	-	21	11	-	11	-	22	-	-	64
Diptera																
Chironomidae (true midges)	11	21	32	75	-	237	387	-	21	258	258	22	205	32	22	280
Tabanidae (horsefly)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
Tipulidae (cranefly)	-	-	21	-	-	-	-	11	-	-	-	-	-	-	-	-
Simuliidae (blackfly)	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-
Oligochaeta																
Tubificidae (Tubifex worm)	-	-	-	-	-	-	-	-	-	22	11	-	43	-	-	-
Turbellaria																
Planariidae (planarians)	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-
Total organisms/square meter	75	43	140	129	86	463	624	129	215	323	335	22	797	414	538	463
Total weight* (gm)/square meter	0.10	0.50	0.16	0.25	0.10	3.76	2.65	4.99	0.37	0.43	4.09	0.05	1.63	1.40	0.95	39.90

*Mollusca weights not included.

TVA Chatanooga 1/19/93

For Southeastern Water Resources
Conference, Nashville, Tennessee
April 14-16, 1959

TVA LAKES AS A FISHERY AND WILDLIFE ASSET

Lawrence F. Miller
Tennessee Valley Authority
Norris, Tennessee

Water is an essential part of wildlife habitat. The kind and amount needed varies by species. For fish, it provides food, oxygen, cover, and a medium of travel; for waterfowl, it supplies food and protection from enemies that cannot fly or swim. Water is essential in the diet of all wildlife. Most birds and animals drink it, but some satisfy their needs by eating succulent vegetation.

Water is also an important food-production medium for many kinds of wildlife. Water-born microscopic plants and animals, for example, feed minnows and other smaller aquatic life, which in turn furnish food for larger fish and other animals. Larger aquatic plants and animals feed waterfowl, muskrats, and larger fish. Frogs and crayfish serve as food for mink and raccoon. Water also provides essential cover and protection for many forms of wildlife.

All in all, a well-balanced water area, along with the vegetation that grows in or near it, supports a rich and varied wildlife population. The extent to which this is true for a series of multi-purpose impoundments depends upon three things: the fertility of the water itself, as determined by the watershed; the extent of pollution; and how water levels are manipulated.

The TVA Reservoirs System

TVA's system of multiple-purpose reservoirs was authorized by Congress to control floods, aid navigation, produce electric power, and provide for national defense. These are the primary objectives; they must receive first consideration. This, then, is the starting point in any fisheries or wildlife development program: Biological resources can be favored only where such action does not interfere with major reservoir uses as outlined in the TVA Act.

Operations of the TVA reservoirs for these statutory purposes follow generally this broad pattern. Most of the drawdown occurs in the late fall and winter, just prior to the period of highest streamflow. Minimum levels on mainstream reservoirs are reached by December 1 and are normally maintained until March 15. After that date they are filled and held full until drawdown starts again in late summer and fall. Tributary storage reservoirs are drawn down in the fall and filled gradually in spring and early summer as streamflow permits. The primary statutory purposes of TVA's water control system mentioned earlier do not permit manipulation of water levels primarily for the benefit of fish and wildlife.

The Tennessee River development has increased water area from 116,000 acres to 600,000 acres. The water control system includes nine dams on the main river and 17 on tributary streams. Mainstream reservoirs have a combined area of about 448,000 acres and vary in size from 6,000 to 158,000 acres. Storage reservoirs have a total area of 151,000 acres and range in size from 604 acres to 34,200 acres. All reservoirs together have a combined shoreline of over 10,000 miles.

Fisheries

The results of many specific fisheries studies have been published and are available. There is time here for only a few general observations.

Creation of additional fishing waters by TVA is a major contribution in the field of aquatic resource conservation and development. The Tennessee Valley has few natural lakes. For this reason, the addition of half a million acres of fishing waters is quite significant. Moreover, these impoundments, although subject to water-level changes for statutory purposes, constitute a much more stable and superior environment than the unharnessed river.

It is this greater stability, together with increased depth and in many instances much less turbidity, that accounts for a 50-fold increase in fishing from a 6-fold increase in water area. This stability, increased depth, and reduced turbidity improves the fishery, not only quantitatively but qualitatively as well. It creates a habitat acceptable to black bass, crappies, walleye, sauger, and white bass where formerly the fish population consisted mainly of sunfish, suckers, bullheads, carp, and buffalo. Before impoundment few black bass, crappie, walleye, and sauger were normally taken from the Clinch River. In contrast, Norris Reservoir now offers in season as good fishing for these species as can be found anywhere. And this same improvement occurred in all storage reservoirs in the system. Total fish production has been increased and the quality of the fishery has been vastly improved. And it is this quality improvement that truly emphasizes the value of the impoundments.

The fish population in mainstream reservoirs differs from that in storage reservoirs in several respects. Mainstream productivity is greater because of more fertile watersheds and to some extent to the heavier load of municipal sewage. The absence of stratification and bottom stagnation permits development of a permanent bottom fauna--insects, worms, and clams. This bottom fauna provides a large volume of food that is not present in the storage reservoirs. All this results finally in the production of a greater number of fishes, but not necessarily the same kinds found in storage reservoirs. Both types of reservoirs support good populations of white bass, crappie, and sauger, but mainstream reservoirs support fewer black bass, virtually no walleye, more sunfishes, and a larger population of food and rough fish species--catfishes, drum, buffalo, and carp.

The presence of the nongame species in large numbers posed a considerable problem in the early days. Over a major portion of the Valley their removal could be effected by hook and line only--netting was illegal in artificially impounded waters. As a result, it was feared that these waters would be taken over completely by nongame species, especially carp and buffalo. Fortunately, this has not happened. Netting of nongame species has been legalized despite the vigorous opposition of sol-called sport fishermen. In addition, maintenance of a clean shoreline for effective and economical mosquito control limits the area of favorable spawning habitat for carp and buffalo.

Perhaps nothing illustrates the increase in fishing more than state records on the sale of fishing licenses. Let's look at some figures for Tennessee.

Year		Number of licenses sold	Value
*1935	Resident	54,355	$ 108,710
	Nonresident	870	1,600
	Total	55,225	$ 110,310
**1958	Resident	558,267	$1,299,638
	Nonresident	165,257	392,507
	Total	723,524	$1,692,145

And this isn't the whole story. Children under 16 fish free in Tennessee. Adults need no license to fish in their home county with natural bait.

The Tennessee Valley sport fish catch, estimated at 10 million pounds a year, generates about $15 million worth of business. In addition, the commercial catch, running between 4 and 5 million pounds a year, is valued at about $1 million. The 6,000 to 11,000 tons of mussel shells harvested each year account for another half million dollars. Seventy-five percent of the mussel shells used by the American freshwater pearl button industry comes from the TVA impoundments.

In the 25 years that have elapsed since Norris Dam began to take shape, the Tennessee Valley has developed into a national sport fishing playground second only to the Great Lakes region. A large proportion of the 36 million man-day visits to these waters in 1958 were prompted by the desire to catch a fish. Fishing is an important factor in the $82 million recreation business that has mushroomed on TVA lake shores.

The TVA lakes are open to year-round fishing for all species. Except for the introduction of new species, there is no artificial propagation.

<u>Waterfowl</u>

Prior to impoundment, the Tennessee River was not a major route for migratory waterfowl and virtually no birds wintered in the area. Now the TVA

*Rates in effect in 1935.
**Rates in effect in 1958.

lakes make a valuable contribution to the conservation and harvesting of waterfowl. Kentucky Lake, in west Tennessee, has become a major flyway for migrating ducks and geese coming down the Ohio River. The east Tennessee and northern Alabama reservoirs supplement the Kentucky Lake flyway by intercepting waterfowl moving in across Kentucky and east Tennessee. This is due in part to the creation of large new expanses of water. More specifically, it is the result of cooperative efforts of Federal and state agencies to improve waters and lands for waterfowl use.

The waterfowl program in the Valley is a cooperative one. Actual development work and management is done by the U. S. Fish and Wildlife Service and the Valley states. TVA's function is primarily investigative. In addition, TVA lands and waters have been made available to Federal and state agencies. TVA also tries to resolve the conflicts that arise as a result of multiple use of the reservoir and the primary interests of the numerous agencies involved.

Some 105,000 acres of land and water have been transferred to the U. S. Fish and Wildlife Service for inclusion in Kentucky Woodlands National Wildlife Refuge, Tennessee National Wildlife Refuge, and Wheeler National Wildlife Refuge. In addition, 90,000 acres have been made available to the conservation departments of Alabama, Kentucky, Mississippi, and Tennessee for state refuges and public shooting areas.

On 24,340 acres of these lands last year the various agencies produced almost 194,000 bushels of grain for waterfowl. As waterfowl food production increases, so does the number of waterfowl wintering in the Valley. In 1935, an estimated 250 ducks wintered here. The wintering population of ducks and geese in 1957-58 was estimated at 212,450 (176,610 ducks and 35,840 geese). This was about 28 percent of the total wintering population in Alabama and Tennessee. On November 9, 1956, an estimated 460,000 ducks and geese were inventoried on TVA lakes.

The waterfowl harvest in the Tennessee Valley has also increased steadily. The estimated waterfowl kill in the Valley in 1957-58 was 5,680 geese and 37,400 ducks. Most of the ducks were mallards; the geese were Canadas. Another indication of the effect of the reservoirs is the increase in duck stamp sales in Alabama and Tennessee. In 1934-35, sales in these two states totaled 9,451; in 1957-58 the figure was 55,145. These figures and other observations show that the Tennessee Valley is fast becoming an important wintering ground for waterfowl, partly because of its own merits and partly because of the deterioration of coastal areas.

In addition to water and land made available for the waterfowl program, TVA has also transferred in excess of 155,000 acres of land to Federal, state, county, and municipal agencies for parks and forests. Much of this land benefits several species of wildlife, including waterfowl in some instances.

<u>Summary</u>

Development of the Tennessee River for flood control, navigation, and power has resulted in a vastly improved fishery. There is much more fishing and better fishing as a result of river impoundment. Worthy of note is the fine black bass (especially the northern smallmouth) and walleye fishery, the great increase in the crappie fishery, and the virtual explosion of the sauger and striped bass populations in mainstream impoundments. A large wintering population of ducks and geese is another tangible result of river impoundment. And although this later development requires land beyond the reservoir margins, the land without the reservoirs would not have effected the change.

The success of the program is due in large part to TVA's basic fact-finding investigations. An equally important factor in this has been the cooperative efforts of the Valley states and their willingness to pioneer and lead the way in the crusade to liberalize fishing regulations.

10-27-59

TVA Chattanooga 1/14/73

SOME FISH FACTS ABOUT THE LITTLE TENNESSEE RIVER AND THE TELLICO PROJECT

Gordon E. Hall, Supervisor of Fisheries
Fish and Wildlife Branch
Tennessee Valley Authority

The Little Tennessee River, 125-mile-long stream in western North Carolina and eastern Tennessee, meanders in its lower reaches through gently rolling farmlands, its flow almost completely controlled by upstream dams. A tributary of the Tennessee River main stream, the Little Tennessee drains an area of 2,627 square miles as it follows its 75-mile course across western North Carolina and 50-mile journey into Tennessee.

Eighteen Dams

The river remained in its natural state until 1913, when the Aluminum Company of America completed its first dam in the area. Today, the Little Tennessee is one of the most highly developed streams in the United States. The river and its tributaries are controlled by 18 dams, with impoundments varying in size from Fontana's 10,500 acres to Dick Creek's 0.2 acre. Total reservoir area is about 20,365 acres. All dams except TVA's Fontana Dam were built by Alcoa, and power is generated at 14 hydroelectric installations.

Fontana Dam, completed in 1944, is the dominant control structure. Located 61 miles above the mouth of the Little Tennessee, it regulates the runoff from 60 percent of the watershed and provides almost complete streamflow regulation downstream, even through Cheoah (built by Alcoa in 1919), Calderwood (1930), and Chilhowee (1957) reservoirs. Except for minor tributary inflow, the lower Little Tennessee has been controlled absolutely by the gates at Fontana for 21 years.

In any 24-hour period, flow in this section of the river can range from 1,350 to 12,000 cubic feet per second, or an average depth variation of more than four feet. Normal operation is minimum flow at night and on weekends and up to maximum flow at other times.

It is along this lower 33 miles of the Little Tennessee--from the river's mouth upstream to Alcoa's Chilhowee Dam--that TVA is planning Tellico Dam and Reservoir. The Tellico project would create a jewel of a lake in a beautiful setting. With its close proximity to the Great Smoky Mountains National Park and the Cherokee National Forest, the new Tellico Reservoir's potential as an outdoor recreation attraction would far surpass any possible use of the stream in its present state.

Dams have created the availability of trout fishing on this section of the Little Tennessee, and the Tellico project would further enhance the over-all fishing potential of the river.

Fish . . .

The Little Tennessee River is not now--and never was--a natural trout stream.

It was a fairly typical east Tennessee stream, and early Alcoa impoundments did not materially affect the fish population of the river, which included bass, catfish, sunfish, and other warm-water species. But with the construction of 480-foot high Fontana Dam, enough cold water was stored to maintain cool water temperatures favorable for trout growth, but not for reproduction, all the way downstream. The best of this trout water existed just below Calderwood Dam, some 17 miles below Fontana, until Alcoa's Chilhowee Dam was completed in 1957. The habitat was ideal and trout growth rates below Calderwood sometimes exceeded those achieved in hatchery ponds.

The most favorable trout water now is found in the first few miles below Chilhowee.

Thus, the trout fishery on the Little Tennessee was created by dam construction. It is maintained by stocking. For example, in 1964 the Tennessee Game and Fish Commission stocked 460,000 trout of various sizes. The year before, 74,000 trout were stocked in the lower Little Tennessee. By comparison, the Clinch River tailwaters below TVA's Norris Dam--another cold-water area made suitable for trout because of dam construction--were stocked with only 35,000 trout in 1963 and with 31,000 in 1964.

In winter and early spring white bass and sauger run up the Little Tennessee out of Watts Bar Reservoir on the mainstream of the Tennessee. The over-all fish population of the Little Tennessee below Chilhowee Dam now consists of about 11 percent trout, 12 percent other game species, and 77 percent rough or commercial species such as buffalo, drum, mooneye, and shad.

Tellico Lake would be ideal for bass, crappie, and sauger, and fishing of this type, in which many more people engage, would increase enormously.

. . . and Fishing

Eighty percent of the Little Tennessee fishing is in the first 14 miles below Chilhowee Dam, according to a survey now being conducted by the U. S. Fish and Wildlife Service in cooperation with the Tennessee Game and Fish Commission and TVA. During the summer trout make up 83 percent of the catch, but in winter and early spring white bass and sauger are dominant.

The survey estimated fishermen spent about 8,000 "fishing days" on the river between June 22 and September 20, 1964. Eighty-six percent of these fishermen had resident Tennessee licenses and lived within 40 miles. Nine percent came from out of state and the other 5 percent were Tennessee residents who lived more than 40 miles away.

The White River Comparison

There is little similarity between the Little Tennessee and the White River in Arkansas, except that the trout fishery in each instance was created by dam construction and is maintained by stocking. As a tourist attraction, trout fishing in the Little Tennessee has not, and cannot, approach the potential of the White River.

White River is stocked with trout over a distance of 112 miles, but the heaviest fishing is in the first 50 miles. About 14 miles of the Little Tennessee is stocked with trout and the bulk of the fishing is in 8 of these 14 miles.

As mentioned above, the Little Tennessee is fished mostly by local fishermen; less than 10 percent are from out of state. White River fishermen are 86 percent non-resident.

White River floating and fishing have a high degree of private commercial development. Similar facilities and services have not developed on the Little Tennessee, and the river does not offer the potential for development on a comparable scale.

Tellico Project

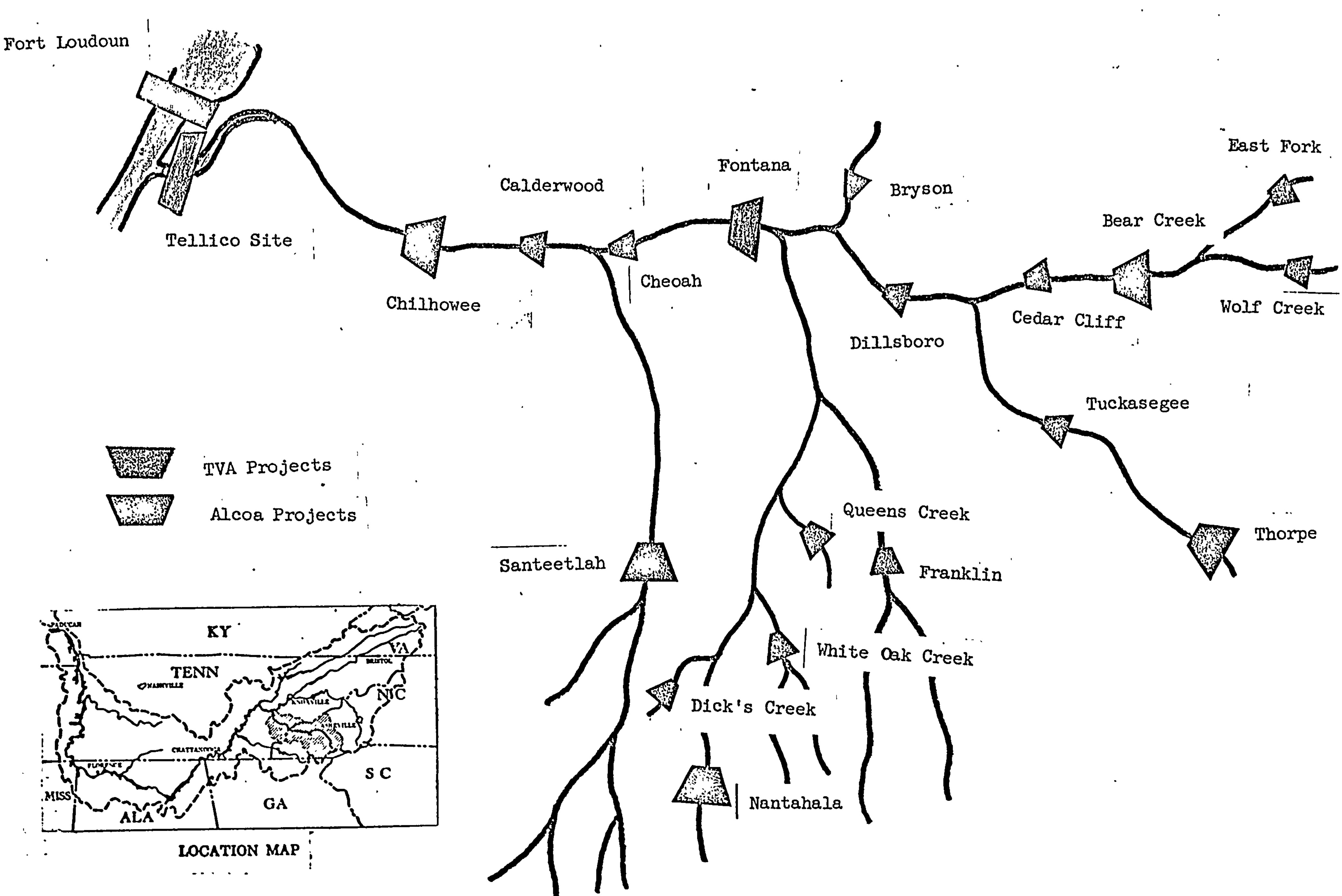
TVA has requested funds to build Tellico Dam on the Little Tennessee, near the mouth of the river and linked by canal with Fort Loudoun Reservoir on the Tennessee River.

This dam would not eliminate trout fishing on the river. The 3 or 4 miles below Chilhowee would provide just as good trout fishing as it does now and considerable habitat for trout would exist further downstream in the Tellico impoundment. Fishing for warm-water species would be very greatly improved. TVA estimates the number of fishing trips in the new lake would be about 150,000 per year.

The trout waters in question occur in a region that now boasts 1,500 miles of trout stream. The Tennessee Game and Fish Commission and the North Carolina Wildlife Resources Commission report 600 miles of trout stream in the Great Smoky Mountains National Park, 300 miles in the Little Tennessee headwaters in North Carolina, 450 miles in the Cherokee National Forest of Tennessee, and 150 miles in nearby reservoirs and tributaries.

-oOo-

LITTLE TENNESSEE RIVER WATERSHED



TVA Chattanooga 1/19/93

TVA-OHES-EIS-72-9

Tennessee Valley Authority
Office of Health and Environmental Science

Appears that wrong sections were copied - shld have been Land Use Section

FINAL ENVIRONMENTAL STATEMENT
WATTS BAR NUCLEAR PLANT
UNITS 1, 2, AND 3

Chattanooga, Tennessee
November 9, 1972

McMinn, Rhea & Meigs Counties

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PREFACE

This detailed statement of environmental considerations, prepared by the Tennessee Valley Authority, evaluates the effects on the environment of the construction and operation of the Watts Bar Nuclear Plant (AEC Docket Nos. 50-390, 50-391) and is made in accordance with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. Section 4331 et seq).

TVA, a corporate agency of the Federal government, and the Atomic Energy Commission, a regulatory agency of the Federal government, have agreed that TVA is the lead agency for the preparation and circulation of detailed statements of environmental considerations for TVA nuclear plants. For the Watts Bar plant a draft statement was circulated for review and comments by other government agencies on May 14, 1971. This was supplemented on April 7, 1972, with additional information responding to AEC's revisions to 10 CFR Part 50, made pursuant to the Calvert Cliffs decision (Calvert Cliffs' Coordinating Committee v. Atomic Energy Commission, 449 F.2d 1109 (D.C. Cir. 1971)).

On May 18, 1971, TVA filed an application for a construction permit for units 1 and 2. At the same time TVA submitted the draft environmental statement along with the preliminary safety analysis report to the AEC in support of the application. In accordance with the lead agency agreement, TVA has consulted AEC in the preparation of this final detailed environmental statement. AEC has concluded that this statement satisfies applicable requirements and that it is adequate to support the licensing action. AEC's letter to this effect follows the preface.

Comments have been received on both the draft and supplement. The information contained in the draft and supplement as well as the agency comments and TVA's response thereto have been incorporated into this statement.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

NOV 7 1972

Docket No. 50-390

Dr. Francis Gartrell
Director of Environmental Research
and Development
Tennessee Valley Authority
720 Edney Building
Chattanooga, Tennessee 37401

Dear Dr. Gartrell:

The Atomic Energy Commission's Regulatory staff has reviewed the proposed Final Environmental Statement for the Watts Bar Nuclear Plant, Units 1 and 2, which was prepared by TVA. The statement was reviewed to determine whether its content meets the guidelines set by the AEC for the preparation of its environmental statements and thus adequately deals with the subject matter in light of the experience gained in our preparation of such statements for other facilities. As a result of this review, it was noted that the treatment given to several topics was less complete than desirable. The areas so identified included:

1) degree of substantiation of need for power, availability of purchased power, and effect of not constructing the Watts Bar Plant;

2) degree of substantiation under alternatives of lack of feasibility of oil-fired plant based on long-term availability of fuel; and

3) consideration of such environmental impacts for alternative plant sites as effect on recreational use and aesthetics, and provision of data supporting comparison of site-related cost factors for alternate sites.

As a result of a meeting held between AEC and TVA representatives on October 30, 1972, TVA has now provided further information supplementing the treatment of the above noted areas. With the addition of this material, we believe that the Watts Bar Environmental Statement satisfies applicable requirements and that it is adequate to support the licensing action.

Sincerely,

A Giambusso

A. Giambusso, Deputy Director
for Reactor Projects
Directorate of Licensing

1.0 INTRODUCTION

TVA is a corporate agency of the United States created by the Tennessee Valley Authority Act of 1933 (48 Stat. 58, as amended, 16 U.S.C. §§ 831-831dd (1964; Supp. V, 1965-69)). In addition to its programs of flood control, navigation, and regional development, TVA operates a power system supplying the power requirements for an area of approximately 80,000 square miles containing about 6 million people. Except for direct service by TVA to certain industrial customers and Federal installations with large or unusual power requirements, TVA power is supplied to the ultimate consumer by 160 municipalities and rural electric cooperatives which purchase their power requirements from TVA. TVA is interconnected at 26 points with neighboring utility systems.

The TVA generating system consists of 29 hydrogenerating plants and 11 fossil-fueled steam-generating plants now in operation. In addition, power from Corps of Engineers' dams on the Cumberland River and dams owned by the Aluminum Company of America on Tennessee River tributaries is made available to TVA under long-term contracts. Figure 1.2-1 shows the location of TVA's present generating facilities and those under construction, as well as the location of the above Corps and Alcoa dams. The approximate area served by municipal and cooperative distributors of TVA power is also shown.

Power loads on the TVA system have doubled in the past 10 years and are expected to continue to increase in the future. In order to keep pace with the growing demand it has been necessary to add substantial capacity to the generating and transmission system on a regular basis. The major system capacity additions since 1949 are shown on Table 1.2-1.

As part of TVA's construction program designed to meet increased requirements for generation, in August 1970 the TVA Board tentatively approved the Watts Bar Nuclear Plant. An application to construct and operate units 1 and 2 was filed with the Atomic Energy Commission (AEC) on May 18, 1971. After extensive review of the Preliminary Safety Analysis Report and other documents by the AEC regulatory staff and the independent Advisory Committee on Reactor Safeguards, an Atomic Safety and Licensing Board is expected to grant a construction permit late in 1972. The Final Safety Analysis Report will be submitted to AEC at a later date, along with a request for authorization to operate both units of the plant at full power level. Under the current schedule, TVA expects to begin to load the nuclear fuel for unit 1 in December 1976. Full operation of unit 1 is expected in the summer of 1977; unit 2 is expected to go into operation in the winter of 1977-78.

As a Federal agency, TVA is subject to the requirements of the National Environmental Policy Act of 1969 (NEPA) which became effective on January 1, 1970. In carrying out its responsibilities under the TVA Act, TVA follows a policy designed to develop a quality environment. As a result of this policy, TVA has long considered environmental matters in its decision making. Offices and divisions within TVA employ personnel with a wide diversity of experience and academic training which enables TVA to utilize a systematic, interdisciplinary approach to ensure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making as required by NEPA. The draft statement on the environmental considerations relating to the Watts Bar Nuclear Plant has been sent to State and Federal agencies for review and comment pursuant to NEPA as implemented by guidelines issued by the Council on Environmental Quality (CEQ) and Office of Management and Budget Circular A-95.

It should be noted that although the two units at Watts Bar will begin operation at different times, this environmental statement considers the plant as operating with both units, in order to accurately assess the impact of the plant on the environment, and so that consideration of the cumulative effects of the plant can be assured.

This statement is arranged in nine principal sections. The first section provides a baseline inventory of environmental information. The following eight sections cover the environmental considerations set out in Section 102(2)(C) of NEPA, as implemented by the CEQ and AEC guidelines. After weighing and balancing the environmental costs, and the technical, economic, and environmental, and other benefits of the project and adopting alternatives which affect the overall balance of costs and benefits by lessening environmental impacts, TVA has concluded that the overall benefits of the project far outweigh the monetary and environmental costs, and that the action called for is the construction and operation of the Watts Bar Nuclear Plant.

1.1 General Information - The purpose of this section is to provide a basic knowledge of the existing environment and the important characteristics and values of the Watts Bar site as it now exists in order to establish a basis for consideration of the environmental impact of the facility.

1. Location of the facility - The plant will be in Rhea County, Tennessee, located on a tract of land adjacent to the TVA Watts Bar Dam Reservation at Tennessee River mile (TRM) 528 on the west shore of Chickamauga Lake about 8 miles southeast of Spring City, Tennessee. The Watts Bar Dam Reservation, together with the 967 acres of additional land required, will comprise approximately 1,770 acres. The proximity of the site to local towns, rivers, and county boundaries is indicated on the vicinity map. (Figure 1.1-1)

2. Physical characteristics of the facility - The plant will consist of the following principal structures: two reactor containment buildings, turbine building, service building, diesel generator building, intake pumping station, water treatment plant, two cooling towers, auxiliary building, transformer yard, 500-kV and 161-kV switchyard, and sewage treatment plant. Figure 1.1-2 shows the general arrangement of these facilities. Figure 1.1-3 is an artist's concept of how the plant will appear on completion of construction. A further description of the site and structures is in Section 2.10, Other impacts.

The 2-unit plant will have a total nameplate electrical generating capacity of approximately 2,540 megawatts. The two reactor containment buildings each house a Westinghouse pressurized water reactor. Nuclear fuel is contained inside each reactor pressure vessel. The fuel is in sealed metal tubes and consists of slightly enriched uranium dioxide pellets. The fission process in the fuel produces heat. Water serves as both the moderator of the fission process and the coolant. The primary coolant water is pumped through the reactor from below the fuel and is heated by contact with the fuel element tubes. The heated coolant flows in four closed-loop circuits through tubes in steam generators and then is pumped back into the reactor. In each steam generator a separate body of water flows in contact with the outside surfaces of the tubes and absorbs heat from the reactor coolant, producing steam to power the turbine generator. The reactor power is controlled by control rods and a soluble neutron absorber boric acid.

The principal ways in which the plant will interact with the environment, discussed later in detail, are:

1. Release of minute quantities of radioactivity to the air and water;
2. Release of minor quantities of heat to Chickamauga Reservoir and major quantities to the atmosphere; and
3. Change in land use from farming to industrial.

3. Environment of the area - The following summary description provides a baseline inventory of the important characteristics of the region.

(1) Topography - The Watts Bar Reservation is a moderately wooded area with rolling hills, located in a valley approximately 10 miles wide, flanked on the west by Walden Ridge (900 to 1,800 feet) and by a series of lower ridges (800 to

1,000 feet) on the east, on the west bank of a bend in the Tennessee River. The nuclear plant will be located in the less-wooded southern portion of the reservation. In the vicinity of the plant the land rises from the water surface (normal maximum level elevation 682.5 feet above mean sea level) to approximately 735 feet above mean sea level.

The highest point on the reservation (elevation 900 feet MSL) is approximately 1/2 mile to the north of the plant.

(2) History - The Watts Bar site is in Rhea County in east Tennessee. Prior to settlement, the area had been lands of the Cherokee, Chickamauga, and Creek Indians. The county was formed by an act of the Tennessee legislature on December 3, 1807. The county boundaries fluctuated frequently in the early years following formation, but eventually stabilized to contain an area of approximately 360 square miles. The original county seat was at Washington, but in 1890 the county seat was removed to Dayton, its present location. To the west and nearer the site location is Spring City, which developed in the latter half of the nineteenth century.

In 1939 TVA authorized construction of the Watts Bar Dam, at a point about 2 miles upstream of the nuclear plant site. The dam has five generators with a total nameplate capacity of 150 MW. All units were operational by 1944.

In 1940 TVA authorized construction of the Watts Bar Steam Plant, 2/3 mile downstream from the Watts Bar Dam. The total nameplate capacity of this 4-unit coal-fired plant is 240

MW. All units were operational by 1945. The plant was seldom used during the 15-year period from 1955 to 1969 due to the availability of more efficient generating units. In the past three years operation has increased but this higher level of use is not expected to continue when Watts Bar Nuclear Plant begins operation.

(3) Geology - Geological studies of the bedrock at the site show that it is overlain by approximately 40 feet of unconsolidated terrace deposits laid down by the Tennessee River when flowing at a higher level. Drilling has shown that the upper half of the terrace deposits consist of sandy, silty clay. The lower half is much coarser, consisting of pebbles, cobbles, and small boulders of quartz or quartzitic sandstone embedded in a sandy clay matrix.

Beneath the terrace cover are the interbedded limestone and shales of the Conasauga Formation of Middle Cambrian Age. Stratigraphically, the Conasauga is overlain to the southeast by 2,500 to 3,000 feet of massive limestone and dolomite of the Knox Group and is underlain to the northwest by 800 to 1,000 feet of sandstone and shale of the Rome Formation. During the geologic past, folding and faulting compressed the Conasauga Formation between the more competent overlying Knox and underlying Rome Formations with the result that the thin-bedded limestones and shales of the Conasauga are complexly folded, crumpled, contorted, sheared, and broken by small faults.

In spite of the structural complexities, the Conasauga Formation will provide a satisfactory and competent foundation for the plant structures. Cores from 56 holes drilled in the plant area indicate no evidence of weathering below the upper

5 feet of rock which will be removed under normal construction procedures. Physical testing, both static and dynamic, has shown that the unweathered rock is capable of supporting loads in excess of those that will be imposed by the plant structures.

The Conasauga Formation at the site is relatively unfossiliferous and has no known areas of unique paleontologic significance.

(4) Seismology - The Watts Bar site lies within the borders of the Southern Appalachian seismotectonic province. Figure 1.1-4 locates the nearest faults in the region.

The nearest local quakes with Modified Mercalli intensities of V were centered 20 miles from the site. The nearest known epicenter of a damaging quake (MM VII) is 75 miles northeast of the site. The maximum intensity to have been felt at the site in the recorded history of the area is probably MM V and certainly no more than MM VI. On the basis of present knowledge, the maximum historic felt intensity was derived from major earthquakes centered at distant points, especially in the Mississippi Valley. Accelerations at the site from a recurrence of any of these shocks would be far less than the proposed design accelerations.

(5) Geography - The Watts Bar site is located in the western portion of the Appalachian Valley physiographic province in the Valley and Ridge subprovince, known locally as the Great Valley of east Tennessee. The Valley and Ridge differ greatly from the adjacent physiographic provinces in geography, physiography,

stratigraphy, and structure. As a physiographic unit, the area is well defined and rather consistent throughout. It is outlined sharply on the southeast by the high front of the Blue Ridge and on the northwest by th abrupt escarpment of the Cumberland Plateau. Its surface is characteriz by long narrow ridges and somewhat broader intervening valleys having a northeast-southwest trend. The ridges are roughly parallel and fairly even-topped. They are developed in areas underlaid by resistant sandstones and the more siliceous limestones and dolomites. The valleys hav been excavated in the areas underlaid by the easily erodible shales and the more soluble limestone formations.

In the vicinity of the Watts Bar site, the Tennessee River, prior to the impoundment of Chickamauga Lake, had entre its course to an elevation of 670 feet above mean sea level. The small tributary valley floors slope from the river up to around elevation 800, while the crests of the intervening ridges range between 900 and 1,000 feet above sea level.

At present no mineral deposits are being w in the Watts Bar area and there is no basis for assuming that any will b developed in the future. In the early part of the present century there was sporadic mining of low-grade iron ore 5 to 15 miles northeast of the site, but these deposits are uneconomical under present market condition Even if they should become economically attractive sometime in the futur they are far enough removed from the area that the presence of the plant would not affect them. Commercially valuable deposits of zinc ores exis in the lower portions of the Holston River basin between Knoxville and Jefferson City, Tennessee. At present these deposits are being activel mined at three locations. The mining operation closest to the Watts Bar

Nuclear Plant is located near Mascot, Tennessee, about 138 miles upstream from the plant site. Coal is produced from the Cumberland Plateau to the northwest of the site, but here again the distance--10 to 15 miles--precludes any interference from the plant.

There is no indicated potential for any oil or gas production in the Watts Bar area. The nearest test wells that have been drilled, without production, are about 10 miles from the plant site. Location of the plant on the Watts Bar site would not interfere with recovery of oil or gas should it be discovered in the area.

(6) Climatology and meteorology - The Watts Bar site is in the eastern Tennessee portion of the Southern Appalachian Region, which is dominated much of the year by the Azores-Bermuda anticyclonic circulation. This circulation is more pronounced in the fall (October) and is accompanied by extended periods of fair weather.

The probability of tornado occurrence at the Watts Bar site is extremely low. For nearly a half-century, 1916-64, there have been no tornadoes recorded in this area of Rhea County. Two tornadoes were recorded in the adjacent Meigs County. Tornadoes in that area generally moved northeastward up the Great Valley, covering an average surface path 5 miles long and 100 feet wide.

Severe windstorms may occur several times a year, particularly during winter, spring, and summer, with winds reaching 35 mi/h and on occasion exceeding 60 mi/h. High wind may accompany moderate-to-strong cold frontal passages 30 to 40 times a year, with maximum frequency in March and April. Strong winds may distinct aquifer in the Conasauga Formation at the Watts Bar site. The shales and limestones are essentially impervious, and the majority of the ground water flows through the terrace deposits overlying bedrock. Water level readings made in the exploration holes show that the water table stands approximately 20 feet above rock in the terrace material.

Preliminary ground water investigations made by measuring ground water levels in exploratory holes in the proposed plant area indicate a ground water gradient sloping toward Chickmauga Lake through the terrace deposits overlying bedrock. Migration of ground water through bedrock is insignificant as shown by the refusal of the rock to accept water at pressures of 50 lb/in^2 by water testing the exploratory holes. TVA will install a series of monitor wells to determine the seasonal ground water fluctuations and to provide baseline data

(b) Surface water - Surface water is derived from precipitation remaining after losses due to evapor tion and transpiration. It can be generally classified as local surface runoff or streamflow.

(c) Water use - The Tennessee River from its head near Knoxville to its mouth near Kentucky Dam is a series of highly controlled multiple-use reservoirs. The primary uses for which this chain of reservoirs was built are flood control, navigati and the generation of electric power. In addition to these, other industrial and public uses have developed, such as sport and commercial fish industrial and public water supply, recreation, and waste disposal.

There are five public water supplies taken from Watts Bar and Chickamauga Reservoirs within the reach from Lenoir City, Tennessee, 43 miles upstream of the site, to

Savannah Utility District, 44 miles downstream of the site. The intakes for two of these systems, Lenoir City, Tennessee, and TVA's Watts Bar Reservation, are located on Watts Bar Reservoir some 43 miles and 2.0 miles, respectively, upstream from the Watts Bar Nuclear Plant site. In the future the Watts Bar Reservation will discontinue using a surface supply and will obtain its potable water supply from the ground water system to be developed to serve the nuclear plant. There are no public water supplies taken from the Tennessee River between the Watts Bar Dam and plant site. The closest downstream surface water supply is Dayton, Tennessee, at TRM 503.8 (25 miles downstream), which serves 6,900 people. The Daisy-Soddy-Falling Water Utility District, which serves about 8,750 people, has a water intake on Soddy Creek embayment of Chickamauga Reservoir about 45 miles below the plant site. The present water intake for the Savannah Utility District, which serves about 1,610 persons, is located on the Tennessee River (TRM 483.6) some 44 miles downstream from the plant site. However, the Savannah intake is to be relocated in conjunction with the construction of TVA's Sequoyah Nuclear Plant, located at TRM 484.5.

The present water supply intake for the City Water Company, which serves a population of about 290,000 in the metropolitan Chattanooga area, is located in the headwaters of Nickajack Reservoir at TRM 465.5 approximately 62 miles downstream from the site and 6 miles downstream from Chickamauga Dam. Studies are being made by a task force organized by the Tennessee Department of Public Health to evaluate the present water supply source and intake location for the City of Chattanooga and recommend any needed action to the State Health Department.

The East Side Utility District had developed plans to locate a surface water supply intake on the Wolftever Creek embayment of Chickamauga Reservoir about 52 miles downstream from the site. However, the district has subsequently decided to continue using its present ground water supply (wells) and has abandoned any definite plans to develop a surface water supply in the foreseeable future.

There are 19 public water systems within a 20-mile radius of the proposed site that depend either totally or in part on ground water as a source of supply. The City of Decatur now obtains its supply from Breedenton Spring, located near the left bank of the Tennessee River about 5 miles downstream from the site. Engineering studies have been made to evaluate the feasibility of a proposed regional water system that would serve both the cities of Decatur and Spring City, as well as numerous small communities and outlying areas. The engineer's report recommends that the intake for such a regional system be located on Watts Bar Reservoir (TRM 532L) about 4 miles upstream from the site. Watts Bar Dam, located between the proposed intake location and the plant site, would preclude any adverse impact resulting from the discharge of liquid effluents from the plant. The ground water supply and the distribution system to be developed for the nuclear plant and the Watts Bar Reservation have been designed so as to be readily incorporated within the regional system whenever it is developed. Public water supply information is included in Table 1.1-13 and the locations are shown on figure 1.1-5.

There are five industrial water supplies taken from Watts Bar and Chickamauga Reservoirs between Tennessee River mile 592 and mile 473. This includes the supply for TVA's Watts Bar Steam Plant which is taken from the Tennessee River at mile 529.3 just downstream from Watts Bar Dam. The industrial water supplies located within a 20-mile radius of the plant and those industrial supplies obtained from the Tennessee River between miles 592 and 473 are summarized in Table 1.1-14. Those industrial supplies in the table marked with a double asterisk also use the supply for potable water within the plant. All other industrial users purchase potable water.

The major industrial water users are downstream from the plant site. These industries withdraw a total of about 53 million gallons of process water from Chickamauga Reservoir each day. Seven industrial water supplies are taken from wells and springs within a 20-mile radius of the plant site. Olin Mathieson Chemical Corporation and Bowaters Southern Paper Corporation obtain water from the Hiwassee River, 22 and 23 miles upstream from its mouth, respectively. The Watts Bar Nuclear Plant will use a maximum of about 86 million gallons of process water each day.

(8) Land use - The existing land use around the Watts Bar Nuclear Plant site reflects the trends of development taking place within the larger Great Valley of east Tennessee. This pattern is essentially the development of small satellite cities focusing on the major metropolitan centers of Knoxville and Chattanooga.

The smaller cities within the economic orbit of these larger centers are growing up along the major transportation routes.

The area around the Watts Bar site is predominantly rural as shown in figure 1.1-3. A 1970 survey of McMinn, Meigs, and Rhea Counties by the TVA Division of Forestry, Fisheries, and Wildlife Development indicates that approximately 57 percent of the land is forested, 38 percent is nonforested, and 5 percent is covered with water.

The minimum exclusion distance for the site is 1,200 meters (∿3,940 feet). No one will be allowed to reside in the exclusion area (figure 1.1-2). The nearest domestic residence is approximately 1,460 meters (∿4,800 feet) from the nuclear plant.

Specific land uses in the surrounding area are discussed below.

(a) Industrial operations - Scattered industry, including two TVA steam plants and a dam, Oak Ridge National Laboratory, and several small industrial plants, have begun to shift the region from an agricultural to a mixed land usage.

The major portion of the Watts Bar Nuclear Plant site will be located on a large tract of land that for many years has been designated by local communities and by state industrial development groups as a potential industrial area. The remainder will be on land best adapted to agriculture.

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FISH HABITAT AND POPULATION CHANGES RESULTING FROM IMPOUNDMENT OF CLINCH RIVER BY MELTON HILL DAM

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INTRODUCTION

This report compares pre- and post-impoundment fish populations and seasonal temperature and dissolved oxygen conditions in the area of Clinch River included in Melton Hill Reservoir. Construction of this TVA dam at Clinch River Mile (CRM) 23.1 was started in September 1960 and the gates were closed May 1, 1963. The impoundment is 44 miles long and has a surface area of 5,720 acres. Annual fluctuation is 5 feet. The backwater extends to within 13 miles of Norris Dam at CRM 80. Watts Bar Reservoir begins almost immediately below Melton Hill Dam.

METHODS AND MATERIALS

TVA biologists investigated preimpoundment conditions at four stations (1, 4, 14, and 16) on the Clinch River (Fig. 1). Gill nets were set 18 times in various seasons between November 1960 and June 1962. Four to six nets of one- to three-inch bar mesh were set at each station and lifted approximately 24 hours later. Total set time was 117 net-days. Fish lengths and weights were recorded by species and scale samples were taken from all fish for growth analyses. Hoop nets were tried, but catches were insignificant and are not included in the analysis. Only one of three rotenone

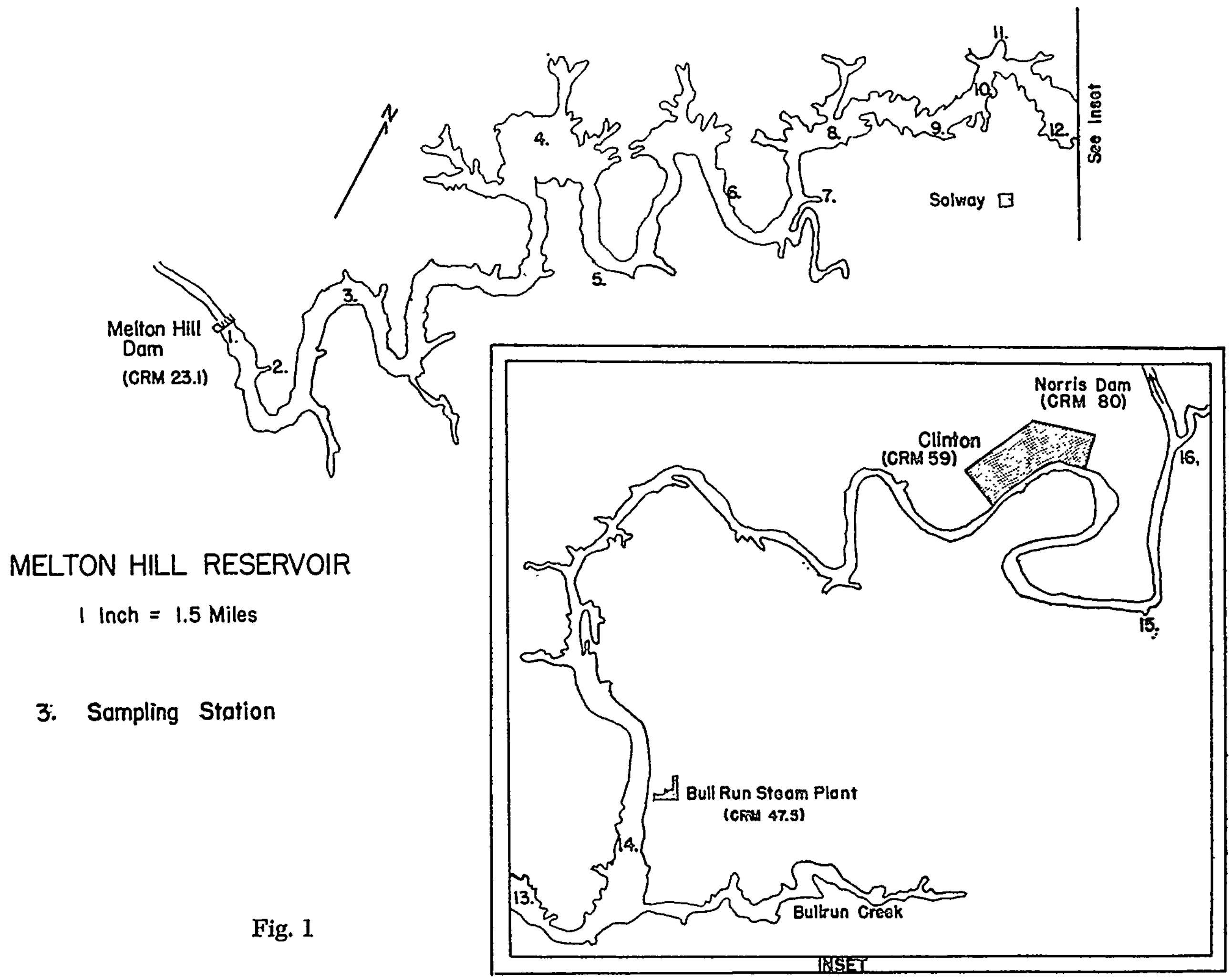

Fig. 1

i

samples (Station 15) produced significant results. Habitat data included surface water temperature at stations 1, 4, 14, and 16 for each sampling period and additional temperature and flow data supplied by TVA Hydraulic Data and Engineering Laboratory Branches.

After impoundment, seasonal gill-net sampling was continued at the same stations. In addition, fish were collected seasonally at six deep-water lake stations (3, 4, 5, 6, 9, and 14) with a 16-foot bottom trawl and at ten shoreline stations (3-5 and 8-14 inclusive) with a 30-foot bag seine. Trawl hauls averaged 5 minutes each and seine drags varied in length. Debris on the reservoir bottom made both trawling and seining difficult. The total sample included 62 gill-net sets, 34 trawl hauls, and 74 seine hauls between November 1963 and October 1964.

Finally, two small coves (Stations 2 and 7) were poisoned with rotenone in October 1964. They were blocked off with a nylon nèt, 300′ x 25′ x ½″ bar mesh to prevent movement of fish into or out of the treated area. The net also served as the outer boundary of the sample which was surveyed to determine exact surface area and water volume. Five-percent emulsifiable rotenone was applied at a concentration of 0.6 ppm and fish were picked up for three days. They were weighed, measured, and counted by species. Scale samples were taken from all species except shad.

Profiles of dissolved oxygen and temperature were developed at each net station from vertical samples taken every five feet. The modified Winkler method was used to determine oxygen; temperatures were read with an electric thermometer. Bottom samples of macroinvertebrates, collected with an Ekman dredge at the three downstream gill-net stations (1, 4, and 14), were screened and preserved in 5% alcohol for later examination. Stomachs for food analyses, taken primarily from fish collected with the trawl, were wrapped in cheesecloth, labeled, and preserved in 10-percent formalin.

TABLE I

GILL-NET COLLECTION DATA FROM FOUR STATIONS IN CLINCH RIVER AND MELTON RESERVOIR—NOVEMBER 1960 - OCTOBER 1964

Station and Date	Game Fish		Rough Fish		Av/net-day			Station and Date	Game Fish		Rough Fish		Av/net-day		
	No.	Wt. (lb.)	No.	Wt. (lb.)	Net days	No.	Wt. (lb.)		No.	Wt. (lb.)	No.	Wt. (lb.)	Net days	No.	Wt. (lb.)
STATION 1				*RIVER*								*LAKE*			
Nov. 14-15, 1960	2	1.3	272	283.4	7	39.2	40.7	Nov. 13, 1963	4	4.8	71	111.7	4	18.8	29.1
Feb. 9-10, 1961	1	1.2	6	4.9	6	1.2	1.0	Feb. 11, 1964	7	4.6	55	78.6	4	15.5	20.8
June 22-23, 1961	3	1.6	105	172.1	6	18.0	29.0	May 18, 1964	8	4.2	71	44.5	4	19.8	12.9
Dec. 14-15, 1961	0	0.0	12	9.7	6	2.0	1.6	Aug. 14, 1964	15	10.1	72	33.5	4	21.8	10.9
								Oct. 6, 1964	23	27.9	40	58.1	2	31.5	48.0
Total	6	4.1	395	470.1	25	16.0	18.0		57	51.6	309	326.4	18	20.3	21.0
STATION 4															
Nov. 9-11, 1960	5	5.9	81	136.9	14	6.2	10.2	Nov. 13, 1963	3	1.5	66	94.5	4	17.3	24.0
Feb. 9-10, 1961	1	1.6	11	17.8	6	2.0	3.2	Feb. 11, 1964	3	0.6	23	21.3	4	6.5	5.5
June 22-23, 1961	1	1.4	46	82.6	6	7.9	14.0	May 19, 1964	14	5.6	119	49.0	4	33.3	13.7
Dec. 14, 1961	0	0.0	2	2.9	6	0.3	0.5	Aug. 14, 1964	10	8.8	93	55.0	4	25.8	16.0
June 16, 1962	2	1.3	8	16.5	6	1.7	3.0								
Total	9	10.2	148	256.7	38	4.1	7.0		30	16.5	301	219.8	16	20.7	14.8
STATION 14															
Nov. 7-9, 1960	4	6.0	174	264.6	8	22.3	33.8	Nov. 13, 1963	20	12.5	27	35.3	4	11.8	12.0
Jan. 6-7, 1961	2	2.6	68	108.4	6	11.7	18.5	Feb. 11, 1964	1	0.4	5	3.5	4	1.5	1.0
June 22-23, 1961	5	2.5	46	88.9	6	8.5	15.2	May 19, 1964	8	5.6	64	36.8	4	18.0	10.6
Oct. 8, 1961	3	1.6	102	163.3	6	17.5	27.5	Aug. 14, 1964	4	2.9	30	10.7	4	8.5	3.4
June 17, 1962	0	0.0	18	41.8	6	3.0	6.9								
Total	14	12.7	408	667.0	32	13.2	21.2		33	21.4	126	86.3	16	9.9	26.9
STATION 16															
Feb. 10-11, 1961	1	0.5	6	3.6	4	1.8	1.0	Nov. 13, 1963	1	0.2	8	13.6	4	2.3	3.5
June 22-23, 1961	18	10.0	113	173.0	6	23.7	30.5	Feb. 11, 1964	0	0.0	4	4.1	4	1.0	1.0
Oct. 8, 1961	16	10.0	215	194.3	6	38.5	34.1	May 19, 1964	20	14.1	114	151.7	4	33.5	41.5
June 17, 1962	3	3.6	111	171.0	6	19.0	29.1								
Total	38	24.1	445	541.9	22	22.0	25.7		21	14.3	126	169.4	12	12.3	15.3
Grand Total	67	51.1	1,396	1,935.7	117	12.5	17.0		141	103.8	862	801.9	62	16.2	14.6

Results

Fish Populations Preimpoundment netting yielded 1,463 fish weighing 1,987 pounds. Rough fish dominated the catch at all stations (Table I). Of the 33 species caught, 21 were rough fishes and at least 12 have commercial value (Table II). The game fish proportion was only 5% by number and 2.6% by weight. Game species included sauger, white bass, white crappie, spotted bass, bluegill, rock bass, warmouth, and rainbow trout. Mooneye were most numerous, followed by gizzard shad, shorthead and silver redhorses, and river carpsucker in that order. Rotenone samples were dominated by gizzard shad, drum, golden redhorse, and norther hog sucker (Table III).

Table II

Species Taken In Gill Nets In Melton Hill Reservoir

Species	Percent by Number		Percent by Weight	
	River	*Lake*	*River*	*Lake*
Mooneye	28.1	—	10.9	—
Gizzard shad	12.5	7.8	5.9	3.0
Shorthead redhorse	10.0	4.8	9.3	4.5
Silver redhorse	7.2	1.4	14.7	4.8
River carpsucker	4.9	0.8	8.8	0.7
Smallmouth buffalo	4.3	1.6	7.0	3.5
Black redhorse	4.2	2.3	4.9	3.6
River redhorse	3.6	0.3	6.5	0.5
Golden redhorse	3.3	1.5	4.3	2.2
Longnose gar	2.9	0.7	6.9	2.5
Northern hog sucker	2.7	0.6	2.0	0.5
Freshwater drum	2.1	1.8	0.6	2.1
Skipjack herring	1.7	29.5	1.2	45.5
Blue sucker	1.6	—	5.7	—
Channel catfish	1.6	1.9	1.3	5.1
Sauger	1.5	0.5	1.3	0.6
Carp	1.4	26.4	3.0	7.0
Rainbow trout	1.3	0.4	0.7	0.5
Black buffalo	1.2	—	2.0	—
Threadfin shad	0.8	0.6	0.1	0.1
Quillback	0.7	0.1	1.0	0.2
White crappie	0.6	1.1	0.1	0.3
Rock bass	0.5	0.1	0.2	T
Bluegill	0.5	1.1	0.1	0.2
Spotted gar	0.2	—	0.8	—
Bigmouth buffalo	0.2	—	0.4	—
White sucker	0.1	2.8	0.1	2.2
White bass	0.1	7.8	0.1	7.1
Spotted bass	0.1	0.2	0.1	0.1
Warmouth	0.1	0.1	T	T
Largemouth bass	—	2.1	—	1.9
Brown bullhead	—	0.1	—	0.1
Redbreast sunfish	—	0.1	—	T
Redear sunfish	—	0.1	—	T
Walleye	—	0.5	—	0.7
Spotted sucker	—	0.1	—	0.2
Highfin carpsucker	—	0.8	—	0.3

Table III

Species Taken In Clinch River Preimpoundment Rotenone Samples.

Species	Percent by Number	Percent by Weight
Gizzard shad	28.7	25.6
Drum	9.3	16.2
Golden redhorse	6.5	24.8
Northern hog sucker	3.9	6.2
Black redhorse	2.5	10.8
Carp	1.1	6.8
Smallmouth bass	1.1	1.1
Smallmouth buffalo	0.6	2.5
Rock bass	0.6	0.5
River redhorse	0.3	1.6
Shorthead redhorse	0.3	0.7
Mooneye	0.3	0.5
Miscellaneous minnows	44.8	2.7

These samples indicated that the future Melton Hill Reservoir would have a large rough fish population and should support a sizeable commercial fishery. Also, considerable seasonal fish movement was expected upstream from Watts Bar Reservoir into the Melton Hill tailwater and through the lock into the reservoir. Game species anticipated in this movement were sauger, white bass, and crappie. Suckers and other species were expected to migrate toward the tailwaters of Norris Dam in the spring.

After impoundment rough fishes continued to dominate gill-net catches, but the proportion of game fishes increased to 14% by number and 11% by weight (Table II). Average catch of game fish per net-day also increased (Table I). Of the five most abundant species, white bass ranked fourth. River herring outnumbered all other species; carp, gizzard shad, and shorthead redhorse ranked second, third, and fifth respectively. Other game fishes caught in the lake were sauger, bluegill, white crappie, spotted and largemouth bass, trout, walleye, and various sunfishes.

The Tennessee Game and Fish Commission has stocked Norris Dam tailwater with trout every year since 1950, and downstream migrants were the nucleus of a population in the headwaters of Melton Hill Reservoir. In addition, almost 130,000 three-inch fingerling rainbow trout were stocked in Melton Hill in 1963. These fish spread throughout the reservoir and some passed through the lock or sluice gates to be caught below the dam.

Trawl and seine samples showed an excellent spawn of many species in the spring of 1963. Small carp, buffalo, carpsucker, white crappie, and shad were abundant at all stations that fall. Gizzard shad were most abundant, followed by carpsuckers, carp, minnows, and bluegill in seine samples and by carp, buffalo, bluegill, and white crappie in trawl samples. Trawls were most successful in the lower part of the reservoir, seines in the upper (Tables IV and V).

TABLE IV

FISH CATCH PER MINUTE BY TRAWL, MELTON HILL RESERVOIR.

Date	Trawl station 3	4	5	6	9	14	Total minutes	Ave. catch per min.
May 21, 1963	—	0.3	—	—	0.1	0.4	37	0.2
Sept. 19, 1963	22.1	205.4	17.6	9.1	7.0	1.3	42	43.8
Nov. 13, 1963	0	0.2	10.4	0.4	2.0	0.5	44	2.3
Feb. 10, 1964	1.9	0	0	0.3	1.5	0.2	46	0.7
May 19, 1964	3.2	8.4	3.2	1.6	86.7	0.7	39	18.5
Aug. 13, 1964	0.3	3.4	34.5	10.3	32.0	0.4	40	11.3
Ave. catch/min.	5.6	31.1	12.8	4.3	15.0	0.6	248	13.0

Species composition of trawl samples

Total catch	3,218 fish
Gizzard shad	46.9%
Carp	34.8%
Smallmouth buffalo	6.6%
Bluegill	4.6%
White crappie	2.8%
14 others	4.3%

TABLE V

NUMBER OF FISH TAKEN IN SEINES, MELTON HILL RESERVOIR.

Date	Number per haul at station 3	4	5	8	9	10	11	12	13	14	Total hauls	Ave. catch per haul
May 21, 1963	—	—	—	2.0	3.0	—	—	—	2.0	—	4	2.5
June 28, 1963	157.5	392.0	605.5	747.0	348.3	0	218.0	120.0	184.0	195.0	13	329.2
Sept. 17, 1963	3.0	15.5	3.5	16.0	38.0	30.5	118.0	—	8.0	583.5	16	94.1
Nov. 14, 1963	5.0	0.5	3.0	9.5	—	26.0	—	—	—	158.0	12	33.7
Feb. 11, 1964	39.5	0	0	0	—	0	—	—	—	0	12	6.6
May 18, 1964	—	1.0	19.0	12.0	—	26.0	—	—	27.0	15.0	7	18.1
Aug. 7, 1964	27.0	13.0	72.0	26.5	—	8.5	—	—	—	20.0	10	23.5
Ave. catch/haul	48.6	45.1	131.5	78.6	161.0	15.6	168.0	120.0	49.6	173.3	74	89.7

Species composition
—of seine samples

Total catch	6,640 fish
Gizzard shad	57.2%
Carpsucker	16.9%
Carp	15.0%
Common shiner	2.4%
Emerald shiner	2.3%
Bluegill	1.6%
White bass	0.9%
18 others	3.7%

No largemouth bass were taken before impoundment, but native stock spawned heavily in 1963 and this species was prominent in sport catches from Melton Hill Dam to Norris Dam. Growth was rapid and some of these young-of-the-year largemouth were 10 inches long and weighed 0.75 pound by October.

Two rotenone samples in October 1964 were dominated by shad. Young threadfins accounted for 78 percent of the number and 52 percent of the weight, gizzard shad 18 percent of the number and 25 percent of the weight. Bluegill, carp, buffalo, largemouth bass, and golden redhorse accounted for most of the remaining weight. The total indicated population of 49 to 158 pounds per acre (Table VI) was low compared with other east Tennessee reservoirs such as Cherokee (206 pounds) and Watts Bar (187 pounds).

TABLE VI

COVE POPULATIONS AS INDICATED BY TWO ROTENONE SAMPLES, MELTON HILL RESERVOIR, 1964.

Sampling area description	Fish Group	No. of Species	No. per acre	Weight per acre
Melton Hill				
Station 2 —	Game	9	197	18
1.8 acres (CRM 24)	Rough	9	94	24
	Forage	3	6,129	116
			6,420	158
Station 7	Game	5	32	1
2.0 acres (CRM 40)	Rough	5	25	5
	Forage	3	2,633	43
			2,690	49
	Grand Average		4,555	103

Species composition of two rotenone samples

	% by Number	% by Weight
Threadfin shad	78.3	52.2
Gizzard shad	17.7	24.8
Bluegill	2.2	5.0
Carp	0.6	4.6
Largemouth bass	0.2	2.8
Smallmouth buffalo	0.2	3.8
Golden redhorse	0.2	2.0
Hog sucker	0.2	1.3
16 others	0.4	3.5

Growth For walleye, largemouth bass, and some other species, preimpoundment growth data were calculated by scale analysis. Except for smallmouth bass, walleye, and bluegill, fish growth before impoundment was generally higher than eastern Tennessee averages (Tables VII and VIII). Average first-year growth was higher for white bass, white crappie, sauger, and largemouth bass.

TABLE VII

COMPARISON OF FISH GROWTH BEFORE AND AFTER IMPOUNDMENT, MELTON HILL RESERVOIR.

Species	Average annual growth in inches				Average first-year growth in inches			
	East Tennessee Valley average	River	Lake	Probability°	East Tennessee Valley average	River	Lake	Probability°
Rainbow trout	—	8.0	9.0		—	5.9	8.1	
Channel catfish	2.3	2.8	2.7	°°NS	4.5	—	—	
Smallmouth buffalo	—	3.0	3.6	NS	—	4.6	4.6	
Carp	—	3.5	3.5	NS	—	3.6	4.6	5.0
River carpsucker	—	3.6	4.0	NS	—	6.2	5.7	
Quillback	—	4.5	5.2		—	9.3	5.5	
Drum	—	4.0	4.0	NS	—	5.8	7.9	
Spotted bass	—	2.9	6.1	0.1	—	2.2	6.6	0.1
White bass	3.0	6.7	6.1	NS	7.9	8.4	9.2	NS
White crappie	2.8	3.4	3.4	NS	2.5	3.3	3.0	
Bluegill	1.5	1.6	2.0	NS	2.1	1.6	2.7	0.1
Smallmouth bass	3.2	3.1	—		4.2	2.9	—	
Largemouth bass	3.3	6.1	7.4		4.7	6.1	8.3	NS
Sauger	3.8	5.5	5.9	NS	7.7	8.8	9.0	
Walleye	4.7	—	—		9.6	8.8	9.8	

° Percentage level of probability (95 or 99%) if significant difference between pre- and postimpoundment growth; no entry indicates insufficient data for comparison.

°° Not significant

TABLE VIII

AVERAGE GROWTH RATES FOR MELTON HILL FISHES — PRE- AND POSTIMPOUNDMENT.

Year class	No.	Calculated average total length (inches) at end of year								
		1	2	3	4	5	6	7	8	9
				River Carpsucker						
Post 58, 60, 63	6	5.7	—	10.9	11.5	—	18.7	—	—	—
Pre 58, 60	2	5.7	9.4	13.9	15.2	17.7	—	—	—	—
				Drum						
Post 61, 62, 63	5	7.9	11.2	—	—	—	—	—	—	—
Pre 61, 62	11	5.8	7.7	—	—	—	—	—	—	—
				Walleye						
Post 62, 63	6	9.8	13.0	14.5	—	—	—	—	—	—
Pre 62	4	8.8	—	—	—	—	—	—	—	—
				Channel Catfish						
Post 54, 56, 62	17	—	5.9	8.2	11.6	14.3	15.4	19.0	17.0	24.9
Pre 54, 59	29	3.6	6.8	9.4	11.8	13.6	14.4	15.3	—	—
				Bluegill						
Post 58, 59, 61, 63	11	2.7	—	5.8	—	7.0	8.0	—	—	—
Pre 58, 59, 61	6	1.6	3.2	4.3	6.2	7.5	—	—	—	—
				White Crappie						
Post 61, 63	20	3.0	7.3	9.5	—	—	—	—	—	—
Pre 61, 62	10	3.3	6.1	—	—	—	—	—	—	—
				Spotted Bass						
Post 63, 64	5	6.6	10.2	—	—	—	—	—	—	—
Pre 58, 59	4	2.2	6.0	—	—	—	—	—	—	—
				Sauger						
Post 62, 63	8	9.0	13.3	14.5	—	—	—	—	—	—
Pre 57, 60	15	8.8	12.3	15.2	17.4	—	—	—	—	—
				Rock Bass						
Pre 54, 56, 59	11	1.8	3.3	5.0	6.5	8.4	8.7	9.6	10.5	—
				Black Crappie						
Post 63, 64	5	3.6	6.5	—	—	—	—	—	—	—
				Rainbow Trout						
Post 61, 63, 64	4	9.0	—	17.3	—	—	—	—	—	—
Pre 61	1	8.0	11.8	—	—	—	—	—	—	—
				Quillback						
Post 60, 63	8	5.5	—	—	16.0	—	—	—	—	—
Pre 60	1	9.3	11.7	13.5	—	—	—	—	—	—
				Smallmouth Bass						
Pre 58, 60	7	2.9	6.5	9.1	12.7	—	—	—	—	—
				Largemouth Bass						
Post 62, 64	48	6.9	11.1	11.9	—	—	—	—	—	—
				Smallmouth Buffalo						
Post 58, 63	17	4.6	8.0	10.8	16.6	15.3	15.6	—	—	—
Pre 57, 62	12	4.6	7.8	10.6	11.6	12.6	13.6	—	—	—
				White Bass						
Post 60, 64	37	9.2	10.9	13.1	18.9	19.9	—	—	—	—
Pre 60, 62	13	8.4	10.8	15.8	—	—	—	—	—	—
				Carp						
Post 58, 60, 63	54	4.6	6.6	8.4	14.4	—	—	—	—	—
Pre 58, 60, 62	36	3.6	8.7	13.5	18.0	20.9	23.2	—	—	—

After impoundment, average annual growth rates of all Melton Hill species for which comparisons were possible exceeded the eastern Tennessee Valley averages. This was also true of average first-year growth rates (Tables VII and VIII).

Water Conditions (Temperature and Oxygen) Preimpoundment surface water temperatures indicated that the upper reaches of the lake at least would have suitable year-round trout habitat (Table IX). The few occasions when temperatures rose above a satisfactory level (70F) could be related to turbine shutoff at Norris Dam and this was not detrimental unless the shutoff continued for a week or more. Even then, deeper pools with cooler temperatures were available where trout could safely stay as long as oxygen levels remained high.

Temperature and oxygen profiles at the uppermost station (16) after impoundment showed generally suitable conditions for trout at all depths throughout the year (Table X). The 4.0 ppm. of dissolved oxygen on February 10, 1964, was considerably below saturation value at 41F, but no plausible reason for this was found. At the other three downstream stations summer surface temperatures were often above 70F and, therefore, too high for trout, but below 10 feet, temperatures were satisfactory. Lake stratification was evident in warm weather in the first 10 feet at station 14, also between 10 and 15 feet at station 4 and near the dam.

TABLE IX

SURFACE WATER TEMPERATURES (°F.), CLINCH RIVER AND MELTON HILL RESERVOIR.

Date	Station 1	4	14	16
11-8-60	—	—	—	50
11-10-60	—	50	—	—
11-15-60	50	—	—	—
1-6-61	—	—	42	—
2-9-61	41	40	—	—
2-10-61	—	—	—	38
6-22-61	64	65	67	70
10-8-61	—	—	68	68
6-16-62	—	63	65	76
Impoundment				
11-15-63	57	58	60	63
2-10-64	42	42	41	41
5-11-64	77	87	81	56
8-13-64	81	74	57	51

NOTE: Temperatures below 70F are satisfactory for trout.

Oxygen concentrations were usually satisfactory for fish at all levels throughout the year, although on May 11, 1964, samples taken near the bottom in the downstream part of the lake showed only 4.0 ppm, which is near the lower desirable limit. The apparent oxygen stratification in November 1963 at stations 14 and 16 while temperatures were uniform from surface to bottom cannot be explained.

TABLE X

DISSOLVED OXYGEN AND TEMPERATURE PROFILES, MELTON HILL RESERVOIR.

Depth	Nov. 15, 1963 D.O. (ppm.)	Nov. 15, 1963 Temp. (°F.)	Feb. 10, 1964 D.O. (ppm.)	Feb. 10, 1964 Temp. (°F.)	May 11, 1964 D.O. (ppm.)	May 11, 1964 Temp. (°F.)	Aug. 13, 1964 D.O. (ppm.)	Aug. 13, 1964 Temp. (°F.)
Station 1								
S	7.0	57	8.0	42	8.0	77	8.0	81
5	7.0	57		42		77		75
10	7.0	56		42	8.0	75	9.0	74
15	7.0	56		42		69	7.0	63
20	7.0	56		42	4.0	65		59
25	7.0	56		42		62	6.5	58
30	7.0	56	9.0	42	5.0	60	6.0	57
Station 4								
S	7.0	—	9.0	42	9.0	87	8.0	74
5	7.0	58	9.0	42			8.5	73
10	7.0	57	9.0	42	6.0		8.5	71
15	7.0	57	9.0	42			6.5	60
20	7.0	57	9.0	42	4.0	72	7.0	58
Station 14								
S	7.0	60	9.0	41	8.0	81	8.0	57
5		60	9.0	41	8.0	73	6.0	57
10	5.0	60	9.0	41	8.0	57		56
15		60	9.0	41	8.0	55	6.0	56
20		60	9.0	41	8.0	54		56
25	8.0	60	9.0	41	8.0	54	6.0	56
Station 16								
S	7.0	63	4.0	41	11.0	56	8.0	51
5	5.0	63	4.0	41	10.0	51	8.0	51
10	9.0	63	4.0	41	10.0	50	8.0	51

Only postimpoundment bottom fauna samples were taken. These showed three macroinvertebrate groups: Tendipedidate, Naididae, and Tricoptera, with tendipeds the dominant group (Table XI).

TABLE XI

MACROINVERTEBRATES PER SQUARE FOOT OF BOTTOM, MELTON HILL RESERVOIR.

Date and Depth	Naididae Station 1	Naididae 4	Naididae 14	Tendipedidae 1	Tendipedidae 4	Tendipedidae 14	Tricoptera larva 1	Tricoptera larva 4	Tricoptera larva 14
11-14-63									
Shallow	4	24	0	56	180	0	0	0	0
Deep	4	0	12	40	0	4	0	0	4
2-10-64									
Shallow	0	4	16	16	20	20	0	0	0
Deep	0	4	8	0	4	20	0	0	0
8-17-64									
Shallow	0	4	16	0	8	8	0	0	0
Deep	0	4	52	0	12	20	0	0	0

The tendipeds were most numerous in the fall at station 4 in water less than 10 feet deep. The Naididae was most numerous in the summer, at station 14 in water more than 10 feet deep. Tricoptera larva were found only once; four were taken during the summer at station 14.

Stomach Samples Stomach sampling, too, was done after impoundment only, and for these species: white bass, largemouth bass, sauger, rainbow trout, channel catfish, drum, and carp (Table XII). The channel catfish diet consisted of minnows, insects, crustaceans, and algae. Trout stomachs contained minnows, insects, and crustaceans. White bass and drum had eaten minnows and crustaceans. Sauger limited their diet to minnows. Most of the carp stomachs examined were empty, but a few contained insects.

TABLE XII

FOOD FOUND IN FISH STOMACHS — MELTON HILL RESERVOIR.

Fish Species	Number Stomachs	Empty Stomachs	Number of stomachs containing: Minnows	Insects	Crustaceans	Algae
Channel catfish	10	8	2	2	1	1
Rainbow trout	2	0	1	2	1	0
White bass	11	5	4	3	0	0
Drum	9	5	1	3	0	0
Largemouth bass	7	1	4	0	2	0
Sauger	4	3	1	0	0	0
Carp	12	9	0	3	0	0

DISCUSSIONS

Changes in the pre- and postimpoundment fish populations are evident (Table XIII). Although rough fish are still dominant (1967), they now account for a smaller proportion of the total population. Spawning and survival of carp, buffalo, carpsuckers, and shad were excellent the first year of impoundment. The two shads are the dominant lake species.

Largemouth bass, absent in preimpoundment samples, were taken during the first spring of impoundment in abundance, and in excellent physical condition. The second spring young-of-the-year were in poor condition and scarce. But second-year fish from the 1963 hatch were still growing rapidly. A scarcity of forage (plankton, insects, etc.) for small fish may have caused the poorer survival the second year.

White crappie, bluegill, and white bass increased in number after impoundment and this trend will probably continue. Large numbers of white bass have been taken only in the lower reaches of the lake. River herring, abundant the first year of impoundment, decreased the second year. Mooneye, numerous before impoundment, have not been taken in lake samples. Walleye showed up for the first time in October 1964, when a few harvestable-size individuals were taken. Catfish are scarce but in good condition.

Trout were scarce in postimpoundment samples but fishermen take them occasionally throughout the lake. These fish are remnants of early plantings. Water conditions are suitable for trout in the upper fifteen miles of the reservoir. Although spawning is not likely to occur, a good trout fishery can be maintained through a regular stocking program.

The physical features of the lake indicate that sport fishing will not be on a par with most mainstream reservoirs. The combination of cold water temperature, low basic productivity (plankton), and relative lack of cover and wide shallow acreas are not conducive to production and maintenance of a large game fish population. However, fishing success at times will probably approach that of tributary reservoirs like Norris.

The abundance of carp, buffalo, and carpsuckers will pose a problem for some time. Commercial seining for these fish in the fall of 1963 was discontinued because of the poor catch and the small average size of fish. As of the fall and winter of 1966-67, observations with electrofishing gear still were not indicative of profitable commercial fishing.

The Bull Run Steam Plant at CRM 47.6 began operating in late 1966 and may have some effect on local fish and invertebrate populations. The warmer discharge from the cooling condenser is expected to attract forage fish and protect shad against killing winter temperatures. Predator fish will move in to take advantage of these concentrations.

A significant difference in the number of predatory fish in Bullrun Creek embayment and the main channel of Melton Reservoir was confirmed with electrofishing gear in the summer of 1966. Summer temperatures in the river are consistently 10 to 20 degrees colder than in the creek embayment, and this is the only physical difference. When conditions were reversed in the late fall of 1966 and the embayment was 10 to 15 degrees cooler than the river, the catch of predators dropped off sharply in the embayment and increased in the main channel.

TVA fishery investigations on Melton Hill Reservoir will be resumed in February 1967, with a year-long study of the effects of Bull Run Steam Plant on the local fish population. The purpose is to determine whether there is a significant correlation between seasonal fish concentrations and one or more of the following factors: temperature, D.O., CO_2, pH, plankton, bottom-dwelling animal communities. Stations above, below, and in the plant discharge basin will be sampled biweekly. In addition, age and growth patterns will receive further study, and information on fish concentrations will be made available to fishermen.

TABLE XIII

FISHES TAKEN IN MELTON HILL RESERVOIR
AREA SAMPLES

Both Before and After Impoundment

Longnose gar	*Lepisosteus osseus*
Skipjack herring	*Alosa chrysochloris*
Gizzard shad	*Dorosoma cepedianum*
Threadfin shad	*Dorosoma petenense*
Rainbow trout	*Salmo gairdneri*
Stoneroller	*Campostoma anomalum*
Carp	*Cyprinus carpio*
Common shiner	*Notropis cornutus*
Whitetail shiner	*Notropis galacturus*
Spotfin shiner	*Notropis spilopterus*
Fathead minnow	*Pimephales promelas*
River carpsucker	*Carpiodes carpio*
Quillback	*Carpiodes cyprinus*
White sucker	*Catostomus commersoni*
Northern hog sucker	*Hypentelium nigricans*
Smallmouth buffalo	*Ictiobus bubalus*
Bigmouth buffalo	*Ictiobus cyprinellus*
Silver redhorse	*Moxostoma anisurum*
Shorthead redhorse	*Moxostoma breviceps*
River redhorse	*Moxostoma carinatum*
Black redhorse	*Moxostoma duquesnei*
Golden redhorse	*Moxostoma erythrurum*
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictis olivaris*
White bass	*Roccus chrysops*
Rock bass	*Ambloplites rupestris*
Warmouth	*Chaenobryttus gulosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieui*
Spotted bass	*Micropterus punctulatus*
White crappie	*Pomoxis annularis*
Logperch	*Percina caprodes*
Sauger	*Stizostedion canadense*
Freshwater drum	*Aplodinotus grunniens*
Banded sculpin	*Cottus carolinae*

Before Impoundment Only

Spotted gar	*Lepisosteus oculatus*
Mooneye	*Hiodon tergisus*
Bigeye chub	*Hybopsis amblops*
River chub	*Hybopsis micropogon*
Warpaint shiner	*Notropis coccogenis*
Blacknose dace	*Rhinichthys atratulus*
Blue sucker	*Cycleptus elongatus*
Black buffalo	*Ictiobus niger*
Blackspotted topminnow	*Fundulus olivaceus*
Dollar sunfish	*Lepomis marginatus*
Greenside darter	*Etheostoma blennioides*
Blueside darter	*Etheostoma jessiae*

After Impoundment Only

Goldfish	*Crassius auratus*
Golden shiner	*Notemigonus crysoleucas*
Emerald shiner	*Notropis atherinoides*
Bluntnose minnow	*Pimephales notatus*
Spotted sucker	*Minytrema melanops*
Highfin carpsucker	*Carpiodes velifer*
Brown bullhead	*Ictalurus nebulosus*
Mosquitofish	*Gambusia affinis*
Largemouth bass	*Micropterus salmoides*
Redbreast sunfish	*Lepomis auritus*
Redear sunfish	*Lepomis microlophus*
Johnny darter	*Etheostoma nigrum*
Walleye	*Stizostedion vitreum vitreum*

Names are according to American Fisheries Society Special Publication No. 2, 1960.

SUMMARY OF EXISTING WATER, SEDIMENT, FISH, AND SOIL DATA IN THE VICINITY OF THE OAK RIDGE RESERVATION

August 18, 1983

Introduction

On April 26, 1983 the Tennessee Division of Water Management requested TVA's assistance in reviewing existing surface water data in the vicinity of the Oak Ridge Reservation. TVA subsequently received a majority of the data from Oak Ridge Operations on June 16. Water, sediment, and fish data (primarily from 1970 through July 1983) were examined for East Fork Poplar Creek, Poplar Creek, Bear Creek, White Oak Creek, Clinch River, and a segment of the Tennessee River (Figure 1). Recent soil samples from the Oak Ridge area were also examined. The primary purposes were to synthesize available offsite* data; evaluate data adequacy for defining specific problems; and determine what additional data are needed.

With the exception of three areas, this review indicated that existing offsite data are generally insufficient to define specific actions other than further sampling and assessment. The three areas of most obvious immediate concern are East Fork Poplar Creek, White Oak Creek, and Jefferson Junior High School. In East Fork Poplar Creek, mercury concentrations in fish exceed the Food and Drug Administration action level, indicating that the State's decision to ban fishing is appropriate. In White Oak Creek, increases in radioactivity during the last few years suggest a continuing source of radioactivity that should be identified and evaluated. At Jefferson Junior High School, soil concentrations of mercury were higher than at any other offsite sampling

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*Department of Energy facilities were not included in this review.

location. Because both mercury concentrations and human activity are high at this site, an immediate assessment of the potential health impact and the extent of contamination should be initiated.

Scope of the Review

Available water, sediment, fish, and soil data were obtained from a variety of sources (Tables 1 and 2). Twenty chemical and radiological parameters were examined (Table 3). Data on groundwater, air quality, effluent discharges, plant and animal conditions, and onsite areas were generally not examined. With the exception of limited PCB data, no information was available for toxic organic compounds.

The available data were reviewed with respect to the following questions:

- What contaminants are present in offsite surface waters and soils and at what levels?
- Where are the highest concentrations?
- How do these concentrations compare with background levels and existing criteria and standards?
- Are concentrations increasing or decreasing (i.e., continuing releases and temporal trends)?
- What additional data is needed to define specific problems and corrective actions?

Chemical Parameters in Water, Sediment, and Fish

Table 4 summarizes the number of water, sediment, and fish samples available for each chemical parameter. This constitutes a substantial data base for overviewing surface water conditions. It is less useful in developing specific conclusions because the data is widely scattered among 44 fish species, 14 years (1970-1983), and six streams (East Fork Poplar Creek, Poplar Creek, Bear Creek, White Oak Creek, Clinch River, and Tennessee River).

Summary statistics were examined for each parameter by stream, river mile, year, and fish species (summaries are available in a separate appendix). Mean concentrations are compared with available criteria and background levels in unpolluted streams in east Tennessee (Tables 5 through 11). These comparisons indicate varying degrees of elevated levels for mercury, chromium, copper, lead, nickel, and PCBs (Table 12).

Water concentrations of mercury and chromium in East Fork Poplar Creek are sufficiently elevated to warrant further analysis. Sediment concentrations of mercury, chromium, copper, lead, and nickel in East Fork Poplar Creek, Poplar Creek, and the Clinch River are generally above background concentrations (Table 13). Concentrations of mercury, chromium, nickel, and PCBs in fish also exceed background levels (Tables 8 and 14). Zinc shows no abnormal levels in the available data for water, sediment, or fish. For other parameters, such as beryllium and toxic organics, the data are insufficient (Table 12). Further sampling of these parameters is needed.

Mercury Concentrations in Water, Sediment, and Fish

Data provided by the Department of Energy indicate that the major discharges of mercury occurred in the late 1950s and early 1960s (Figure 2). As indicated above, the current level of mercury in sediment and fish in some areas is significantly above background levels. For water concentrations, recently observed levels in East Fork Poplar Creek are near or below detection limit values (e.g., Figure 3). Since most of the recent data were reported at a detection limit generally above the EPA criterion for the protection of aquatic life, a conclusion regarding current discharges to East Fork Poplar Creek is not possible.

Mercury concentrations in sediment are highest in East Fork Poplar Creek, with a mean concentration exceeding 45 μg/g in the upper reach. Concentrations decrease with downstream distance to approximately 1.0 μg/g in Watts Bar Reservoir (Figures 4 through 12). Limited data for Bear Creek and White Oak Creek have an average concentration of approximately 2.0 μg/g. Background concentrations in unpolluted streams in east Tennessee generally range from 0.05 to 0.2 μg/g. The data are not sufficient to define temporal trends (Figure 13).

Sediment concentrations of mercury in the Tennessee River upstream of the Clinch River average 0.27 μg/g. Mean concentrations downstream of the confluence are significantly above this level through Nickajack Reservoir (Table 15).

These observations suggest the need for core sediment sampling from East Fork Poplar Creek through Guntersville Reservoir, including Bear Creek and White Oak Creek. The sampling should include an analysis of particle size distribution, deposition dating, and variations in mercury concentration with depth. This information will allow an analysis of sediment transport and a determination as to whether the Clinch River is the source of elevated downstream mercury concentrations.

Mercury concentrations in fish follow a pattern similar to that in sediment. Concentrations are highest in East Fork Poplar Creek and decrease with downstream distance (Figures 14 through 16). Concentrations in East Fork Poplar Creek average 1.1 μg/g for all species and 1.2 μg/g for all bluegill, exceeding the Food and Drug Administration action level of 1.0 μg/g. Concentrations in Poplar Creek, the Clinch

River, and the Tennessee River (immediately downstream of the Clinch River) are generally below the FDA action level, but above background concentrations. Concentrations are higher for larger fish with some observations exceeding 1.0 μg/g (Figures 17 through 27). In Bear Creek and White Oak Creek, limited data show mean concentrations of 0.36 and 0.65 μg/g, respectively. Examination of the data by stream reach for selected species by year indicates no obvious temporal trend (Figure 28).

Based on these data, further sampling is recommended for larger fish of selected species (i.e., bottom feeders) in Poplar Creek, Bear Creek, White Oak Creek, the Clinch River, and Watts Bar Reservoir.

Mercury Concentrations in Soil

Mercury concentrations in soils and dredged sediments in the Oak Ridge area were measured in recent months. As of August 1, 1983, TVA had received 182 sample results from 15 identifiable areas. The locations appear to be somewhat random and dictated more by reports of dredge material placement than systematic sampling. The results indicate elevated concentrations in several areas (Table 16 and Figure 29). The highest concentrations are at Jefferson Junior High School (i.e., the mean concentration of 125 μg/g in one set of data compares with expected background levels of less than 0.5 μg/g). Since the potential for human activity in this area is high, an immediate assessment of the potential health threat and areal extent of contaminated soil should be initiated. Other areas of lesser concentrations should also be examined, as well as other areas of high human activity which may have been the recipient of contaminated dredge materials. Selected sampling of East Fork Poplar Creek, Poplar Creek, and Clinch River floodplains and their plant and animal populations is also recommended.

Radiological Parameters in Water, Sediment, and Fish

Discharges of radioactivity to White Oak Creek reached a peak in the late 1950s and generally declined since that time (Figure 30). More recent data show above background levels in the Clinch River downstream of the mouth of White Oak Creek at CRM 20.8 (e.g., Figure 31 for Sr-90). Data for Cs-137 and H-3 show similar results. Concentrations since about 1978 have generally increased, but the cause is not clear (e.g., river flow rates, sediment resuspension, groundwater leachate, or sampling inconsistencies). Although no public water supplies are located on the Clinch River below Melton Hill Dam, the reach is classified for domestic and industrial water supply. If water was regularly consumed from the Clinch River near the mouth of White Oak Creek, doses could be in the range of natural background levels (150 mrem/year). Based on the elevated concentrations observed, the stream classification, and the possibility of a continuing release (e.g., groundwater leachate), sampling and analyses should be conducted to determine whether continuing releases exist, their significance, and possible corrective actions.

Cesium has a greater tendency to be concentrated in fish than tritium or strontium. Figure 32 illustrates reported concentrations in selected fish species at various locations in the Clinch River during 1978. The highest values occur at the mouth of White Oak Creek (CRM 20.8). A person who regularly catches and eats fish from this area would be expected to receive only low additional radiation doses from Cs-137 compared to those from natural sources. However, since concentrations are elevated in this area, further data and analysis of the possible combined radiation dose and its significance is recommended.

In 1962 and again in 1977 sediment cores were collected at CRM 7.5. Results of the 1962 analysis are shown in Figure 33 (fig. 3, ORNL-3721, Supp 2B). At CRM 7.5, the river is turning slowly to the left such that most of the sediment and deposited radioactivity is located from about 200 feet to 450 feet from the left bank on the inside of the turn. The 1977 study collected sediment at locations of 40 to 150 feet from the left bank. As the 1962 study indicates, relatively low activities were found in these locations. Thus, it appears that at this one river location, the highest activity sediment may not have been sampled in 1977.

The highest activity in 1962 sediment core samples 4, 5, 6, and 7 occurs at depths of about 4 feet and decreases at both shallower and deeper levels. This may indicate that most of the radioactivity measured in these core samples came from Cs-137 which peaked in 1956 (Figure 34--fig. 6, page 24, ORNL-3721, supp 2B). Since the levels of highest activity are generally deep in the sediment, they are somewhat isolated from fish and reentrainment in water.

Data on the radioactivity in bottom sediments were collected by Oak Ridge National Laboratory from 1954 through 1961 at many locations on both the Tennessee and Clinch Rivers. Cs-137 data from 1961 are shown in Figure 35 (table 8, page 65, ORNL-3721, Supp 2A). The Clinch River, upstream from White Oak Creek, has a Cs-137 sediment activity of slightly greater than 1 pCi/g. From the entrance of White Oak Creek to the Tennessee River, the activity ranges from about 40 to over 100 pCi/g. Figure 36 (fig. 9, ORNL-3721, Supp 2A) shows Cs-137 concentrations in bottom sediment in 1961 at different locations in the Tennessee River. The activity upstream of the entrance of the Clinch River is about

1 pCi/g but rises to over 30 pCi/g immediately downstream of the Clinch River. The activity decreased with increasing downriver distance until background levels were reached in the Kentucky Reservoir. Data from the 1977 sediment study were not collected for the same locations, but appear to follow the same general trend.

In 1978 and 1979 the sediment in both White Oak Lake and White Oak Creek from the lake to the Clinch River was sampled and analyzed for concentrations of several radionuclides. Radionuclide concentrations are elevated in both locations. Figure 37 (fig. 15, page 43, ORNL-5878) gives an average of Cs-137 concentrations in various depths of sediment samples collected downstream of White Oak Dam. The highest concentrations, near the surface, are about 50 Bq/g or about 1300 pCi/g.

A study of the radionuclides in the sediment of the East Fork Poplar Creek was conducted in 1974. This study found only very low concentrations of uranium. The study also measured mercury concentrations in the sediment and found only low concentrations. Studies conducted since 1974 of mercury in soils and sediment from this creek have found higher mercury concentrations. Data since 1974 from limited radionuclide studies of these soils and sediments are not sufficient to conclude that there are not also high uranium concentrations.

For plutonium, above background concentrations exist in some sediments in the Clinch and Tennessee Rivers. Slightly elevated concentrations are also measurable in both fish and water. However, because concentrations are low and because ingested plutonium is not efficiently incorporated into the body, calculated doses are less than 0.1 percent of the natural background dose.

Limited data are available on radionuclides in Bear Creek. These data do not indicate a significant radiological hazard.

Based on these observations, any offsite areas suspected of being contaminated by dredge material from East Fork Poplar Creek, Bear Creek, or White Oak Creek should be examined for fission products, uranium, and plutonium. Excessive concentrations may suggest mitigative actions. Such an evaluation may require new sediment analyses to ensure that areas of highest concentrations are considered.

Major Conclusions

Mercury and Other Trace Contaminants:

1. East Fork Poplar Creek--Mercury concentrations in fish generally exceed the FDA action level. Sediment concentrations are substantially above background levels. Alternative corrective actions should be evaluated. Additional data are needed to identify trends. Concentrations of chromium, nickel, and toxic organics in fish and sediment should be examined further.
2. Poplar Creek and Lower Clinch River--Mercury concentrations in fish and sediment are above background levels. Additional data are needed to identify trends and determine whether concentrations for specific fish species exceed the FDA limit. Additional data are also needed for chromium, nickel, and toxic organics.
3. Bear Creek and White Oak Creek--Limited data for fish and sediment indicate that mercury levels may be elevated. Additional data for mercury and toxic organics are needed to define the levels present and their significance.
4. Tennessee River--Sediment samples downstream of the Clinch River show elevated mercury levels, at least as far downstream as Nickajack

Reservoir. Core samples from Watts Bar, Chickamauga, Nickajack, and Guntersville Reservoirs are needed to determine concentration variations with depth, past trends in deposition, and whether the Clinch River is the source of this mercury.

Offsite Lands:

5. High mercury concentrations were found in soil samples from some areas in the vicinity of Oak Ridge. Detailed sampling of these areas is needed to determine the areal extent of significant contamination. Each area should be examined to determine whether corrective actions are necessary.
6. Areas suspected of containing dredge material from DOE facilities, East Fork Poplar Creek, Poplar Creek, White Oak Creek, Bear Creek, or the Clinch River should be sampled for mercury, toxic organics, and radioactivity. Floodplains and their indigenous populations should also be sampled.

Radiological Contaminants:

7. East Fork Poplar Creek, Poplar Creek, and Bear Creek--Insufficient data are available. Screening samples of water, sediment cores, and fish should be obtained to more accurately determine the levels present.
8. White Oak Creek and Lower Clinch River--Available data indicate that radioactivity exceeds background concentrations. Significant increases observed in Clinch River water concentrations during recent years are inconsistent with reported releases over White Oak Dam. Seepage from low-level burial sites may partially account for this increase. The significance of the elevated levels observed in water, sediment, and fish needs to be examined further.

9. Tennessee River--Sediment samples downstream of the Clinch River show radioactivity above background concentrations. The levels, which decrease moving downstream and may be slightly elevated as far as Pickwick Reservoir, are not believed to pose a threat to public health.

SUMMARY OF ASSESSMENT AND MITIGATION PLANS

I. Evaluate existing data and related information
   A. Surface waters (water, sediment, fish, biota)
   B. Groundwater - onsite and offsite
   C. Wastewater sources and discharges
   D. Land (soil, plant, animal) - onsite and offsite

II. Prepare comprehensive offsite assessment plan
   A. Data collection and routine monitoring
   B. Data analyses
   C. Transport and fate
   D. Risk assessment

III. Prepare comprehensive onsite assessment plan

IV. Initiate data acquisition/monitoring programs and subsequent analyses as identified in the comprehensive plans

V. Evaluate alternative corrective actions

VI. Develop mitigation plan

VII. Implement mitigation plan
   A. Corrective actions
   B. Followup analyses of mitigation success

ENVIRONMENTAL MONITORING AND ASSESSMENT
KEY ELEMENTS AND OBJECTIVES

I. Data Collection
   - A. Historic--contaminant identification and time periods
   - B. Screening--detect abnormal concentrations
   - C. Detailed--areal extent of excessive levels
   - D. Routine--regulatory compliance, trend assessment, and abatement success

II. Data Analysis
   - A. Assessment--significance of observed levels
   - B. Transport and Fate--mechanistic transport, food chain uptake
   - C. Recommendations--evaluate controls, cleanup, health impacts

III. Risk Assessment
   - A. Public Health--potential impacts to man
   - B. Environs--potential environmental impacts

ADDITIONAL DATA NEEDS

- Review historic information on materials handling and disposal.
- Assess onsite disposal sites.
- Characterize wastewater discharges.
- Standardize future routine monitoring.
- Sample selected fish species from East Fork Poplar Creek through Chickamauga Reservoir.
- Collect core sediment samples from East Fork Poplar Creek through Guntersville Reservoir.
- Identify possible toxic contaminants present and include scans and specific measurements in fish and sediment analyses.
- Evaluate existing groundwater data and conduct additional monitoring as necessary.
- Perform detailed sampling of highly contaminated land areas and screening sampling of areas of suspected contamination.

Appendix I - Figures

OAK RIDGE VICINITY MAP

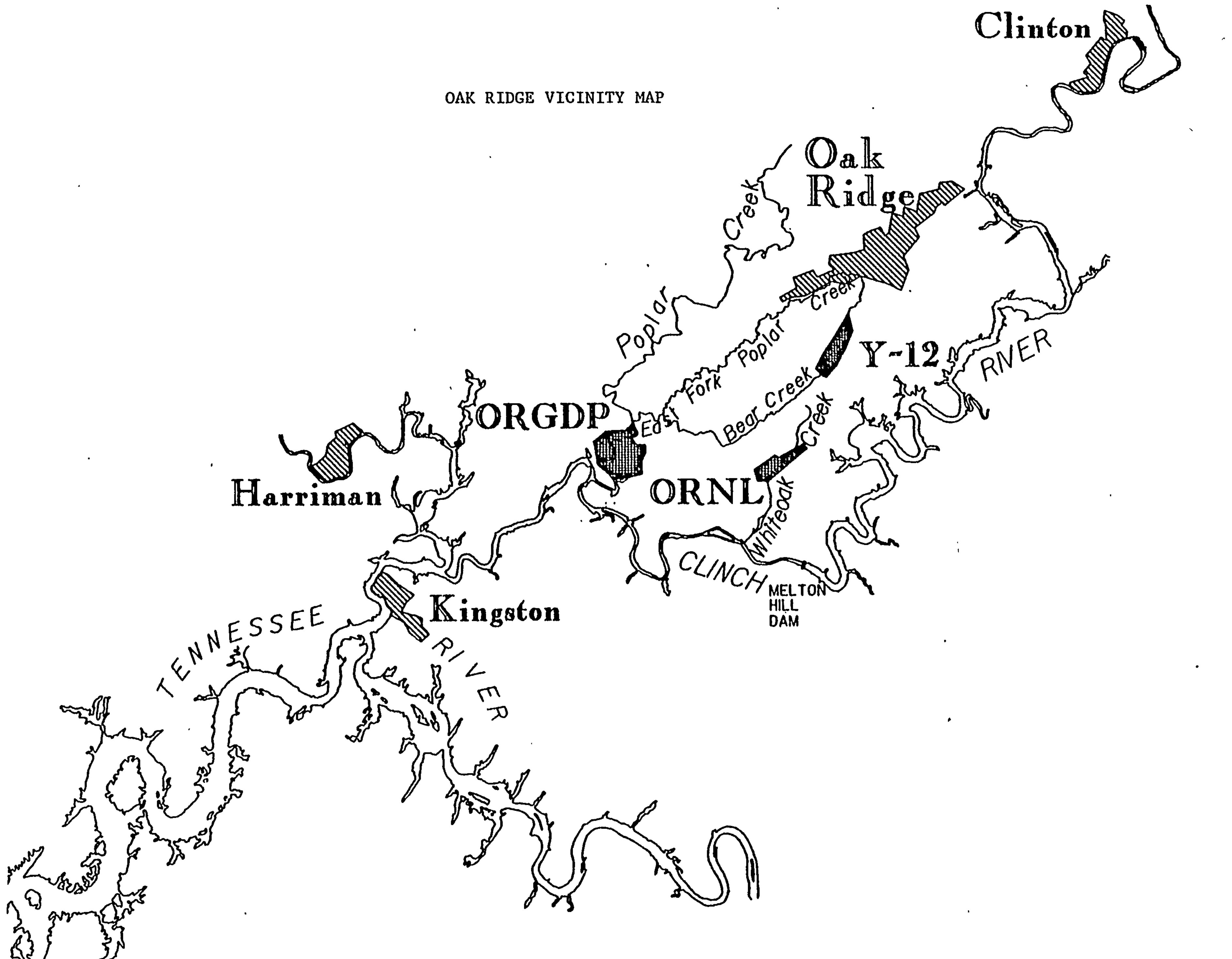
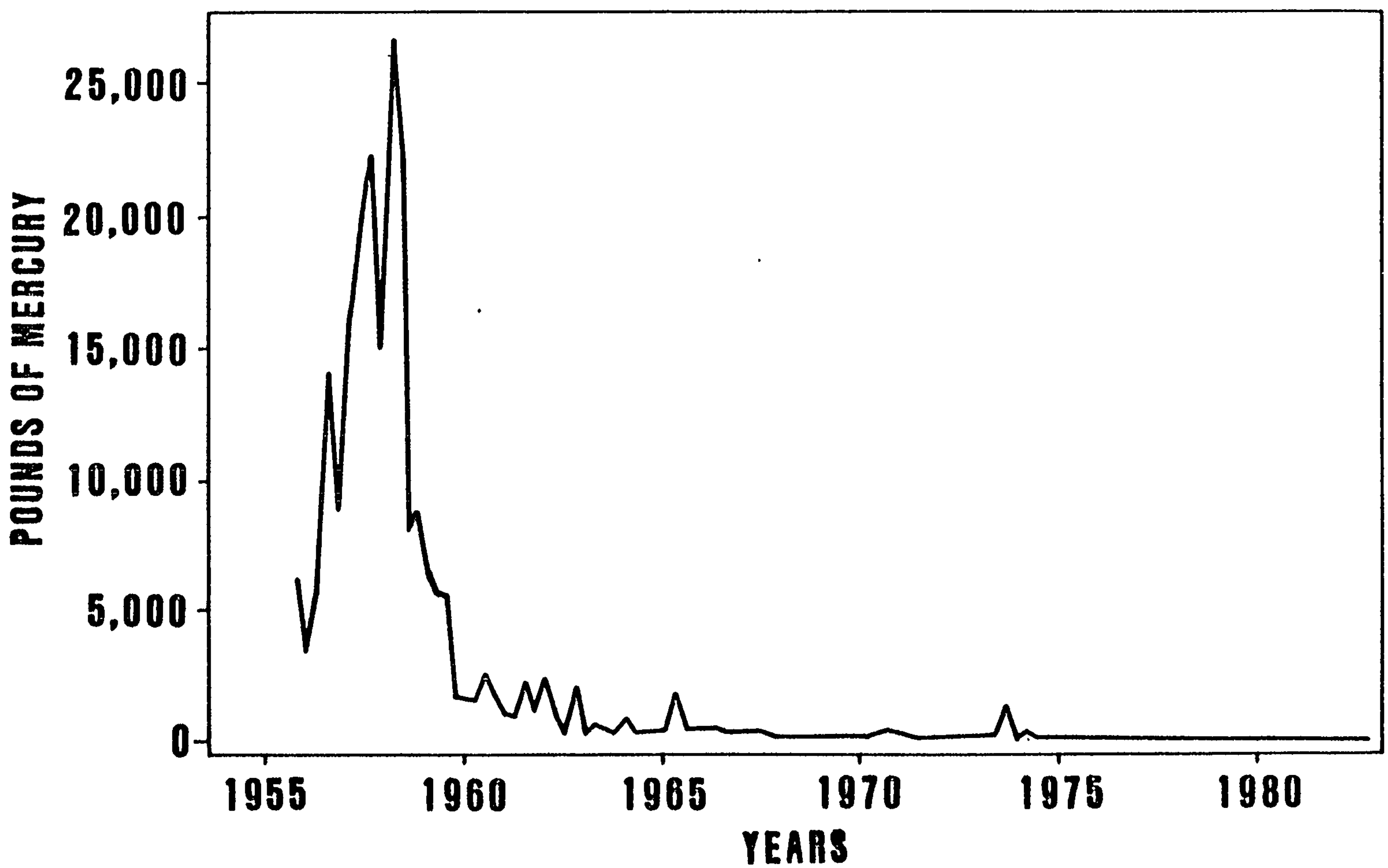


FIGURE 1



MERCURY LOSSES TO EAST FORK POPLAR CREEK

FIGURE 2

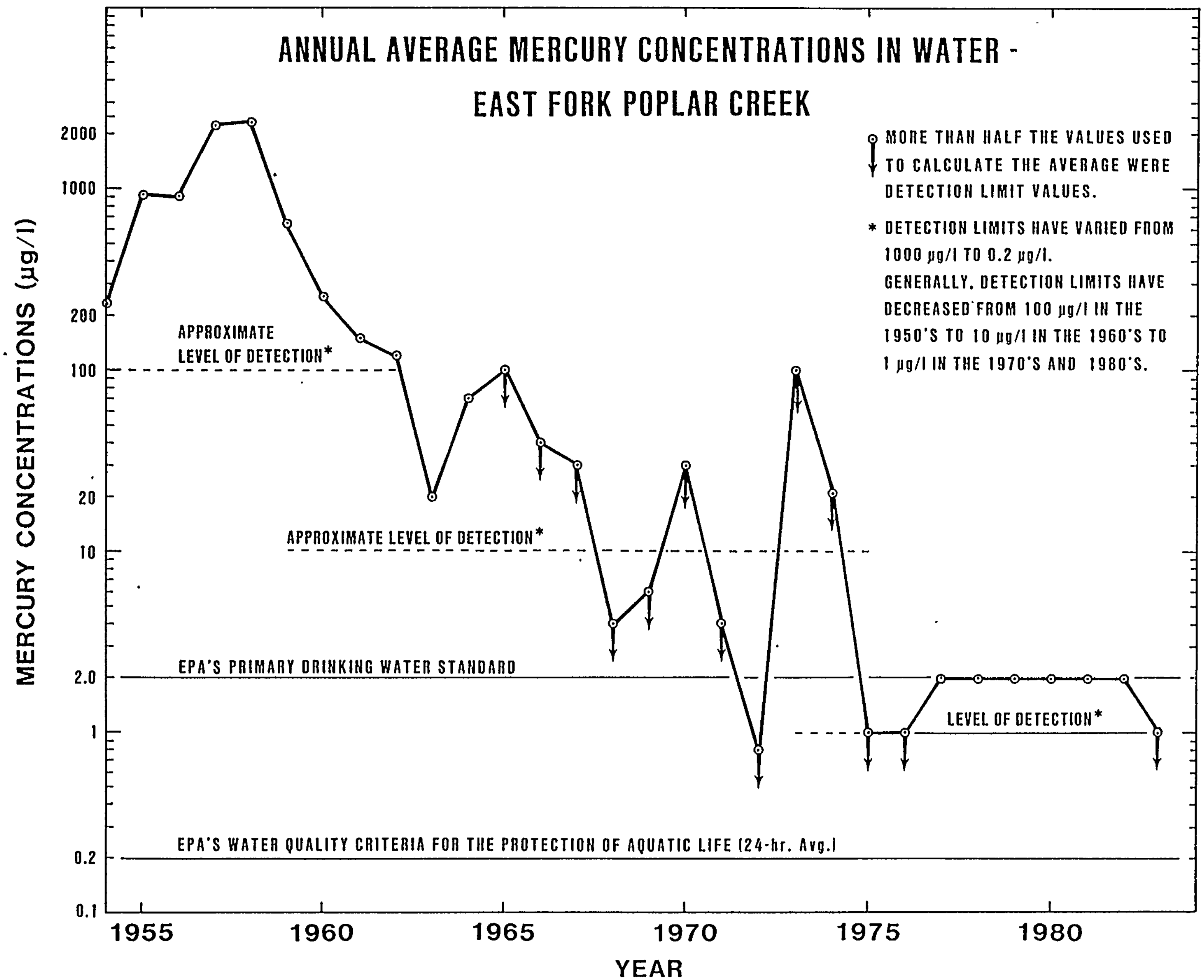

ANNUAL AVERAGE MERCURY CONCENTRATIONS IN WATER -
EAST FORK POPLAR CREEK
MORE THAN HALF THE VALUES USED TO CALCULATE THE AVERAGE WERE DETECTION LIMIT VALUES.
* DETECTION LIMITS HAVE VARIED FROM 1000 µg/l TO 0.2 µg/l.
GENERALLY, DETECTION LIMITS HAVE DECREASED FROM 100 µg/l IN THE 1950'S TO 10 µg/l IN THE 1960'S TO 1 µg/l IN THE 1970'S AND 1980'S.
APPROXIMATE LEVEL OF DETECTION*
APPROXIMATE LEVEL OF DETECTION*
EPA'S PRIMARY DRINKING WATER STANDARD
LEVEL OF DETECTION*
EPA'S WATER QUALITY CRITERIA FOR THE PROTECTION OF AQUATIC LIFE (24-hr. Avg.)
MERCURY CONCENTRATIONS (µg/l)
2000
1000
200
100
20
10
2.0
1
0.2
0.1
1955
1960
1965
1970
1975
1980
YEAR

FIGURE 3

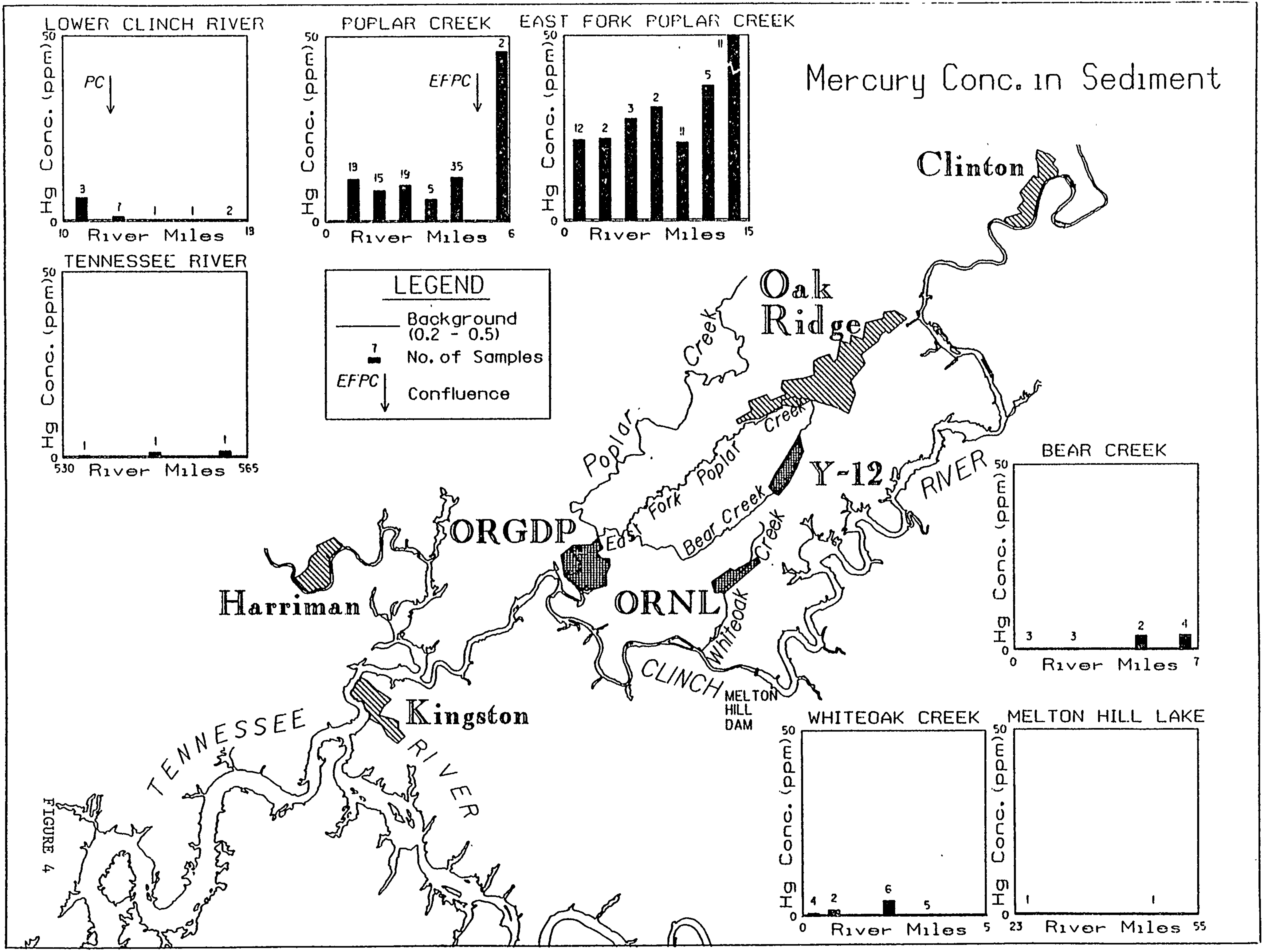
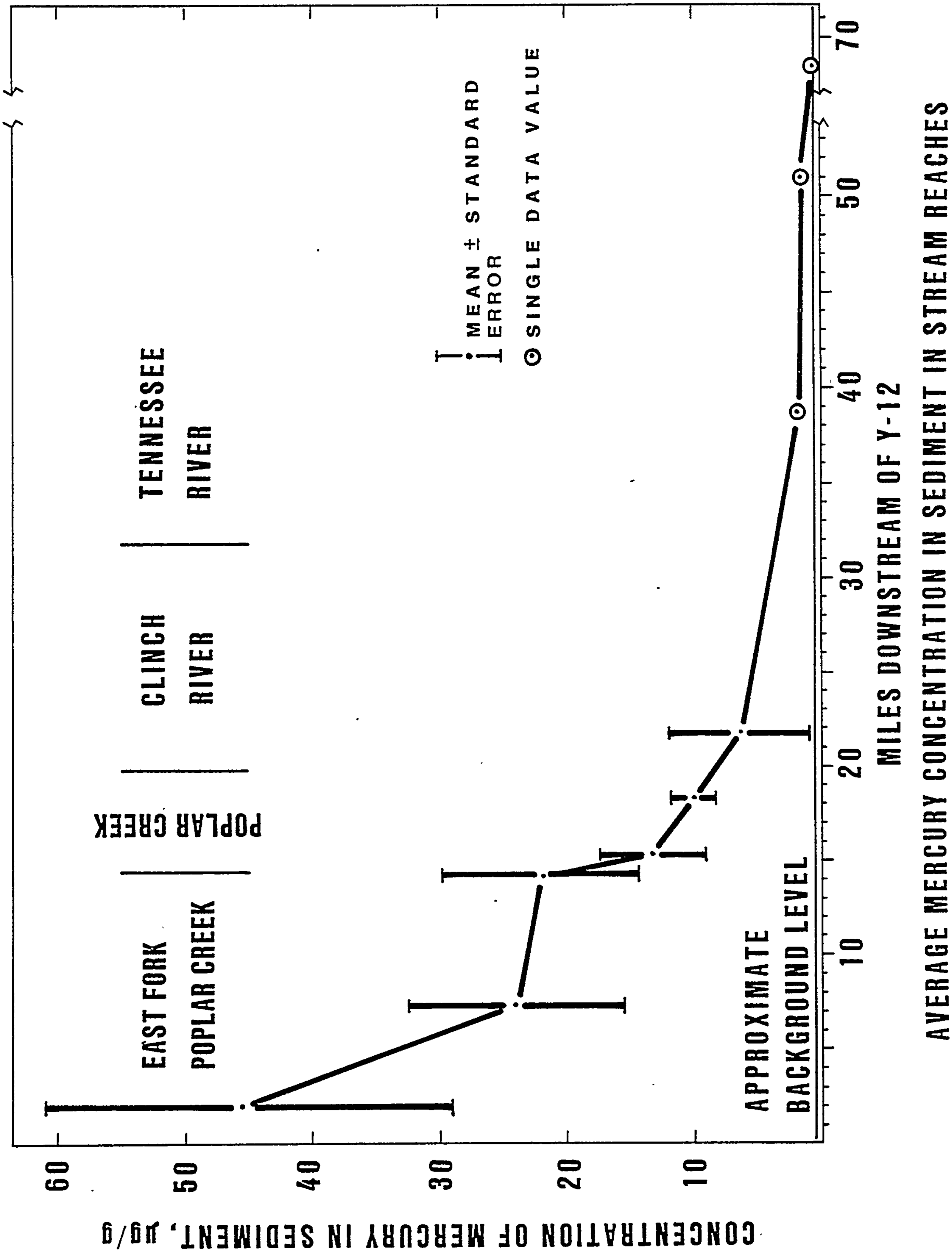

Mercury Conc. in Sediment
LOWER CLINCH RIVER
Hg Conc. (ppm)
PC
River Miles
POPLAR CREEK
EFPC
EAST FORK POPLAR CREEK
TENNESSEE RIVER
LEGEND
Background (0.2 - 0.5)
No. of Samples
Confluence
BEAR CREEK
WHITEOAK CREEK
MELTON HILL LAKE
Clinton
Oak Ridge
Y-12
ORGDP
ORNL
Harriman
Kingston
Poplar Creek
East Fork Poplar Creek
Bear Creek
Whiteoak Creek
CLINCH RIVER
MELTON HILL DAM
TENNESSEE RIVER

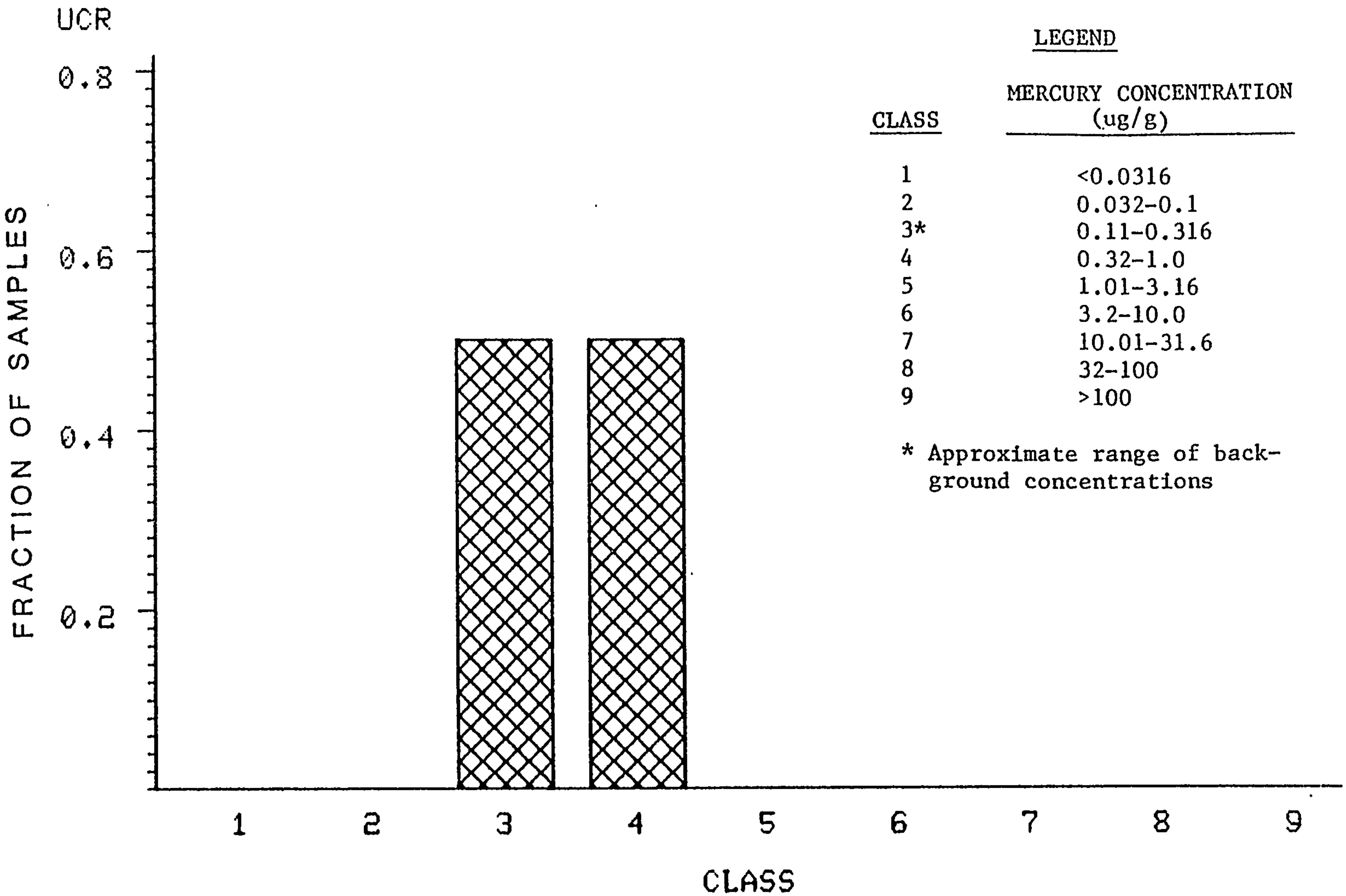
FIGURE 4



EAST FORK POPLAR CREEK
POPLAR CREEK
CLINCH RIVER
TENNESSEE RIVER
MEAN ± STANDARD ERROR
SINGLE DATA VALUE
APPROXIMATE BACKGROUND LEVEL
CONCENTRATION OF MERCURY IN SEDIMENT, µg/g
MILES DOWNSTREAM OF Y-12
AVERAGE MERCURY CONCENTRATION IN SEDIMENT IN STREAM REACHES

FIGURE 5

UPPER CLINCH RIVER SEDIMENT DATA



LEGEND

CLASS	MERCURY CONCENTRATION (ug/g)
1	<0.0316
2	0.032-0.1
3*	0.11-0.316
4	0.32-1.0
5	1.01-3.16
6	3.2-10.0
7	10.01-31.6
8	32-100
9	>100

* Approximate range of background concentrations

FIGURE 6

EAST FORK POPLAR CREEK SEDIMENT DATA

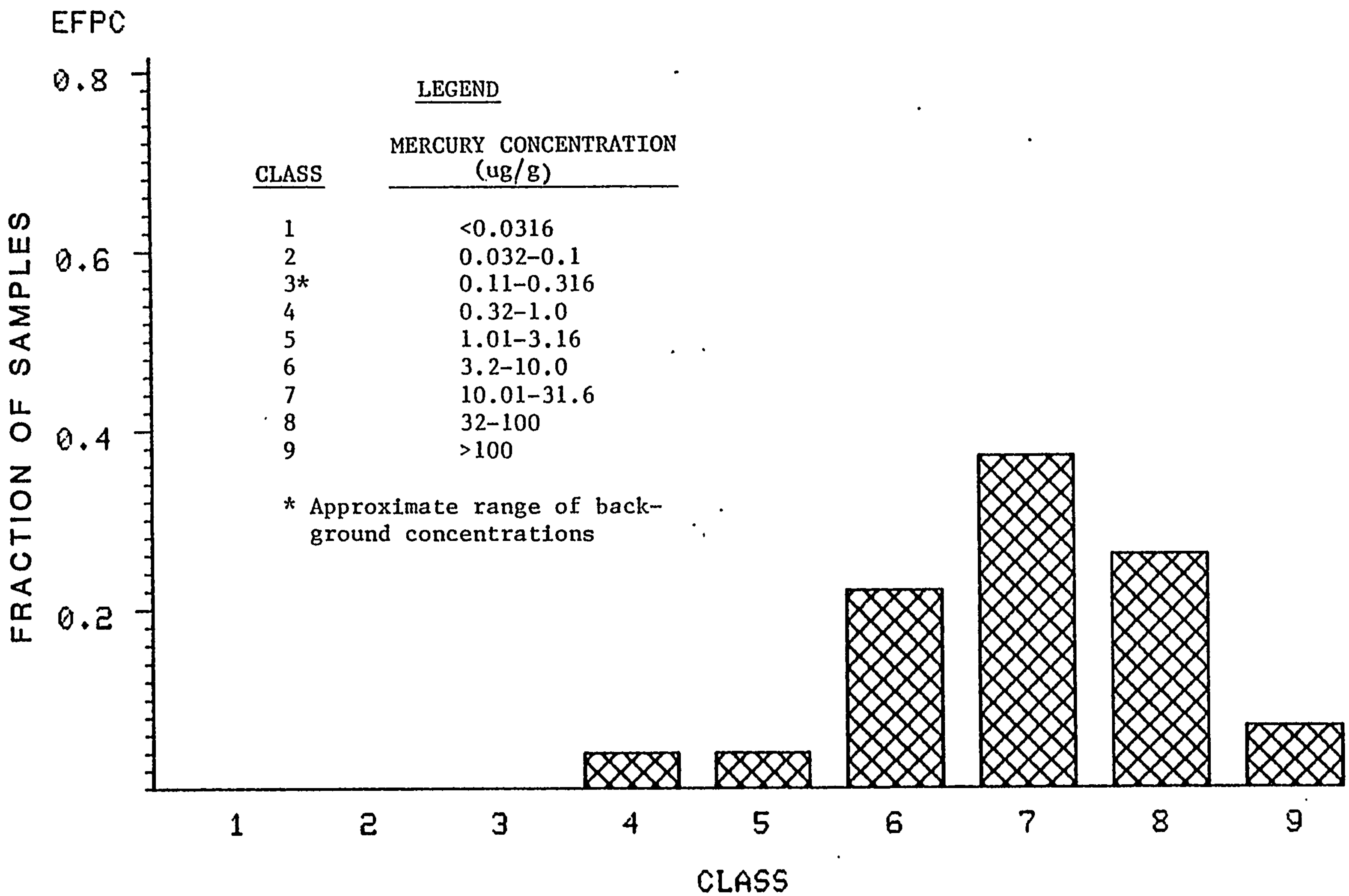


FIGURE 7

POPLAR CREEK SEDIMENT DATA

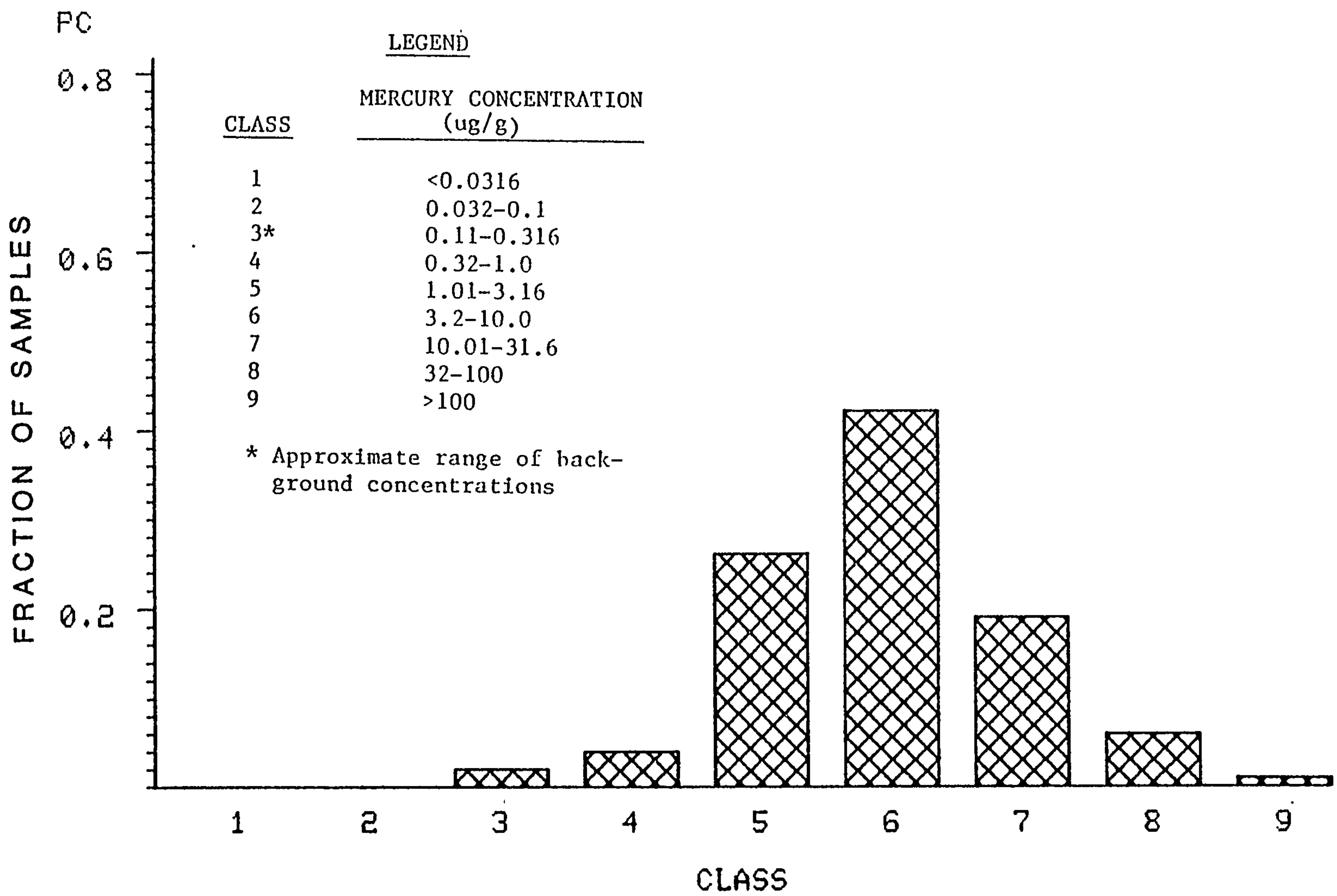


FIGURE 8

LOWER CLINCH RIVER SEDIMENT DATA

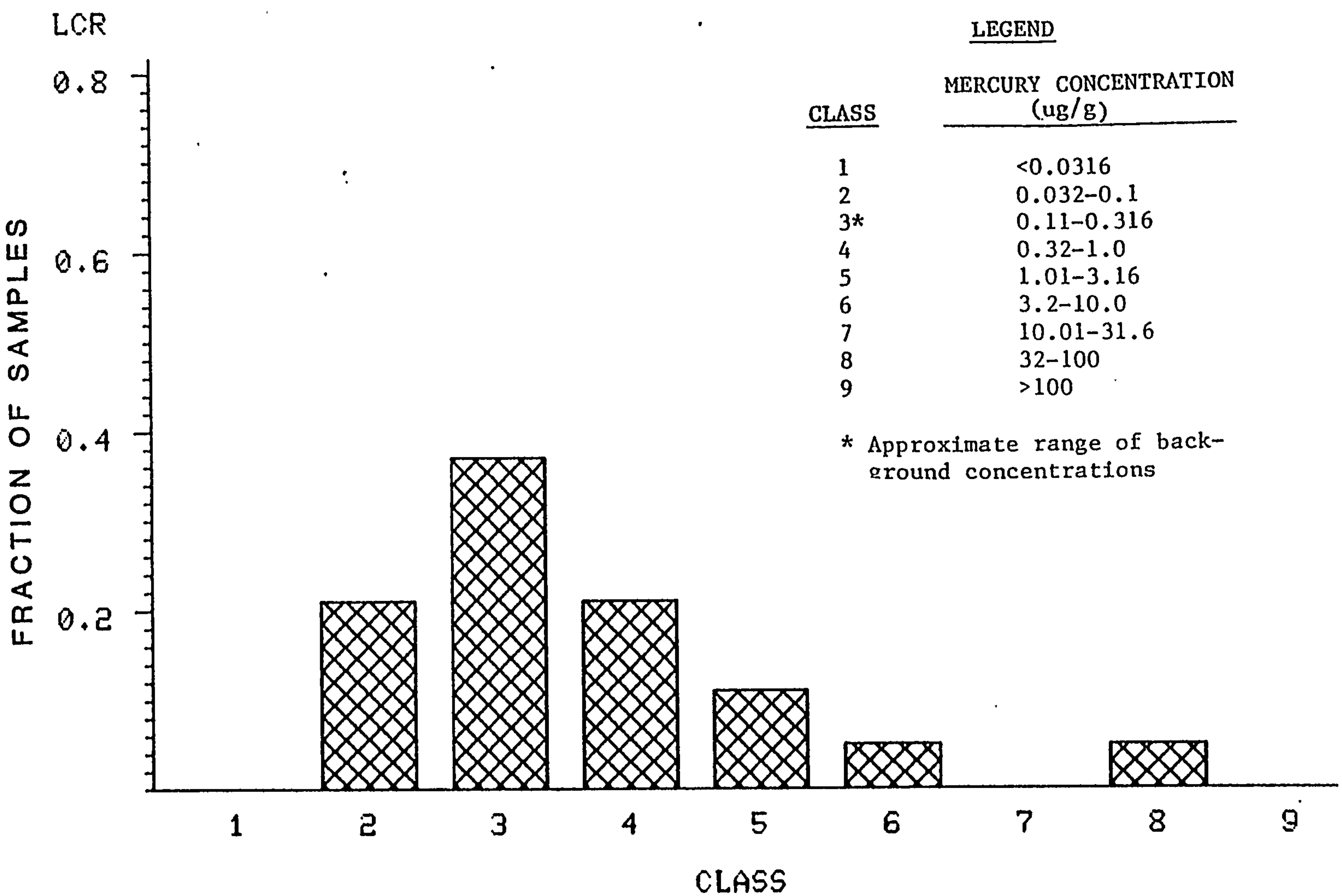
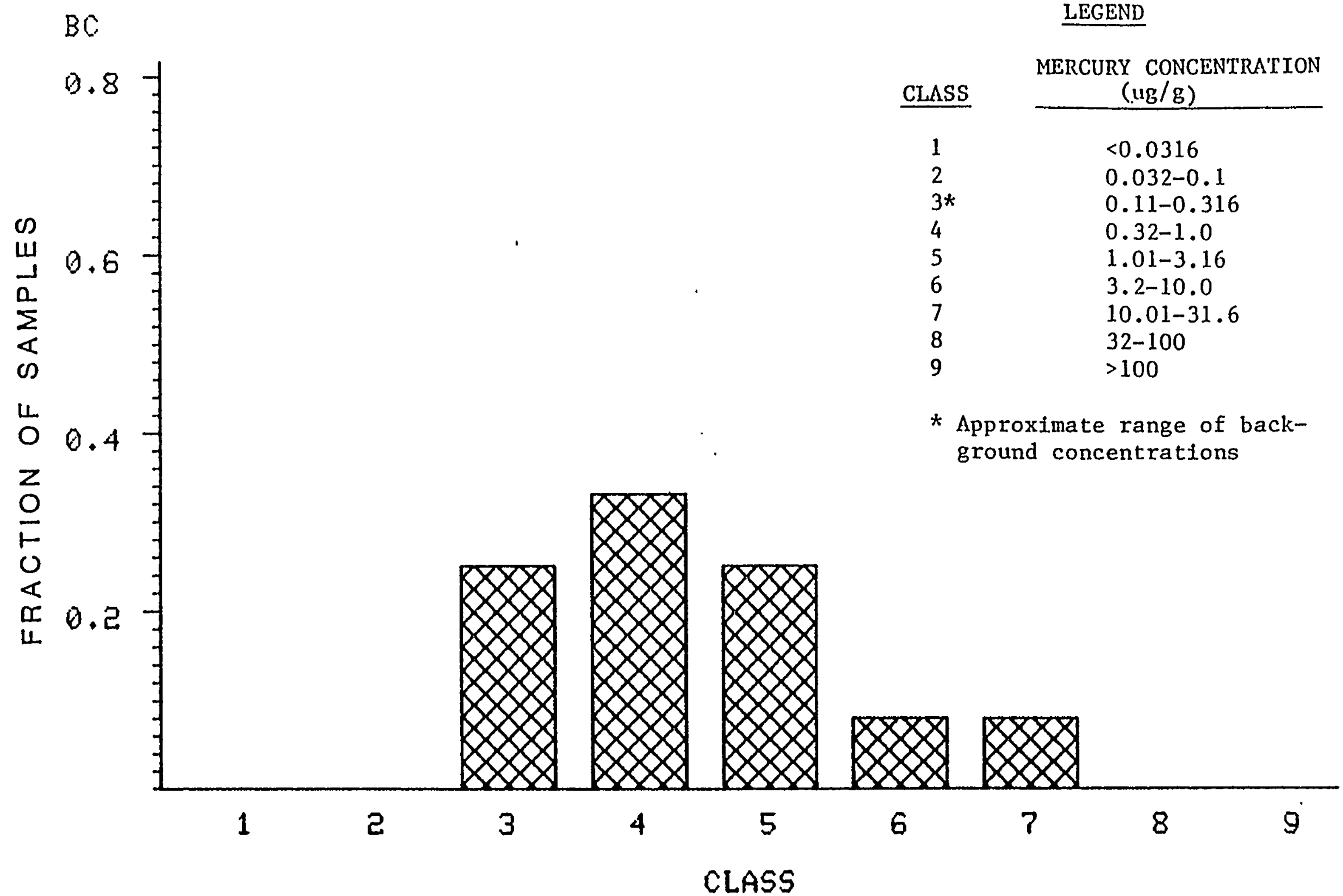


FIGURE 9

BEAR CREEK SEDIMENT DATA



LEGEND

CLASS	MERCURY CONCENTRATION (ug/g)
1	<0.0316
2	0.032-0.1
3*	0.11-0.316
4	0.32-1.0
5	1.01-3.16
6	3.2-10.0
7	10.01-31.6
8	32-100
9	>100

* Approximate range of background concentrations

FIGURE 10

WHITE OAK CREEK SEDIMENT DATA

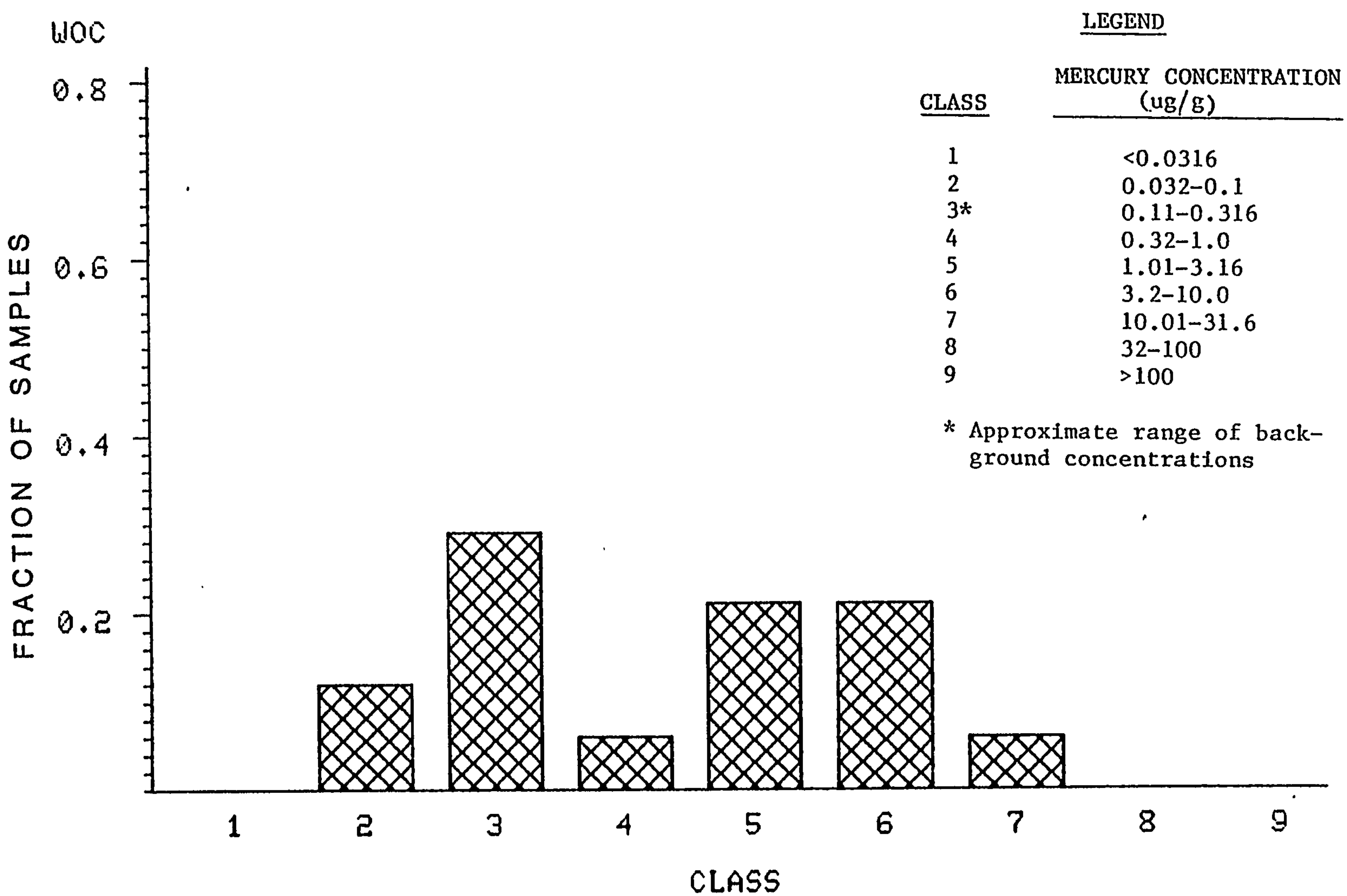


FIGURE 11

TENNESSEE RIVER SEDIMENT DATA

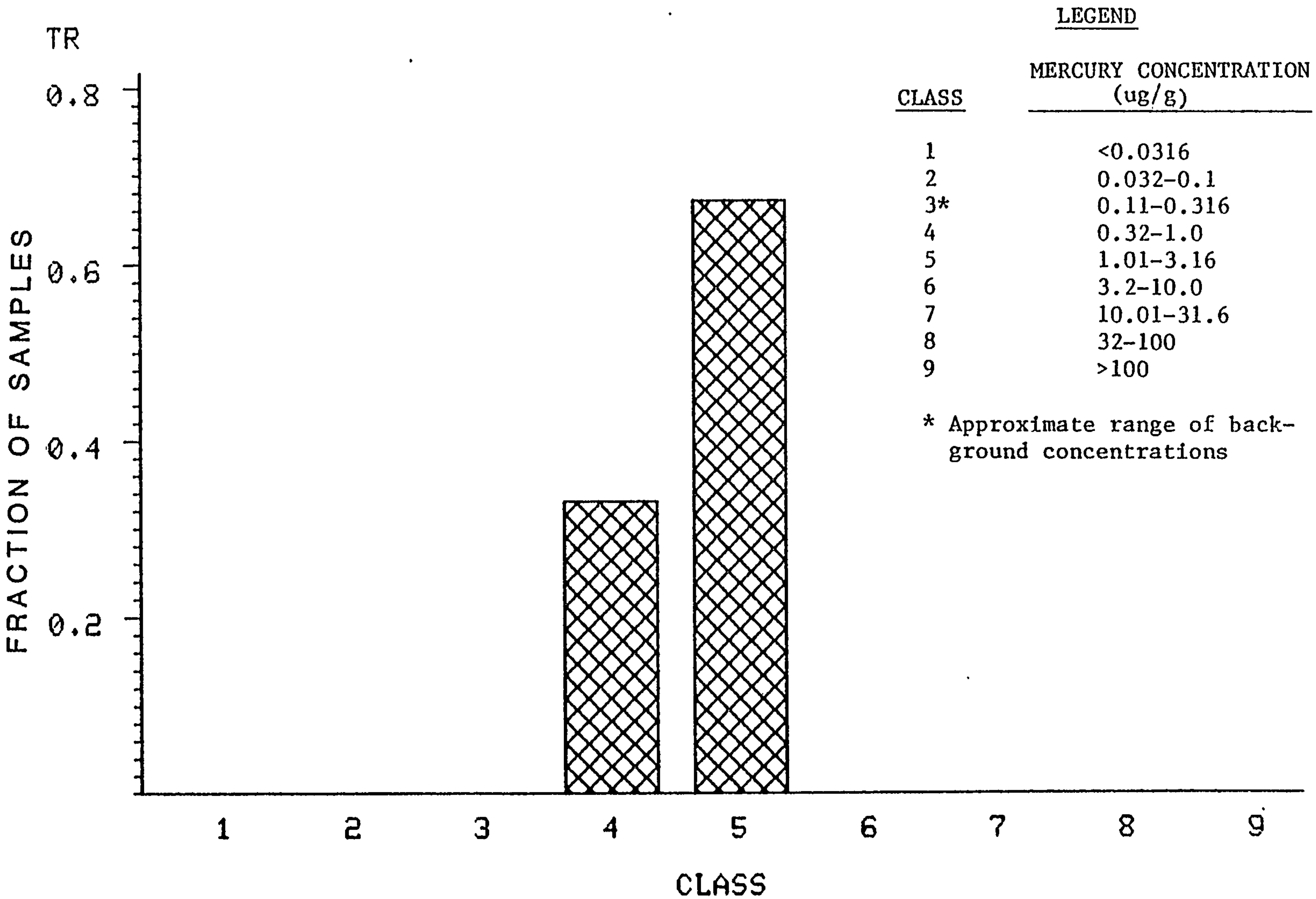
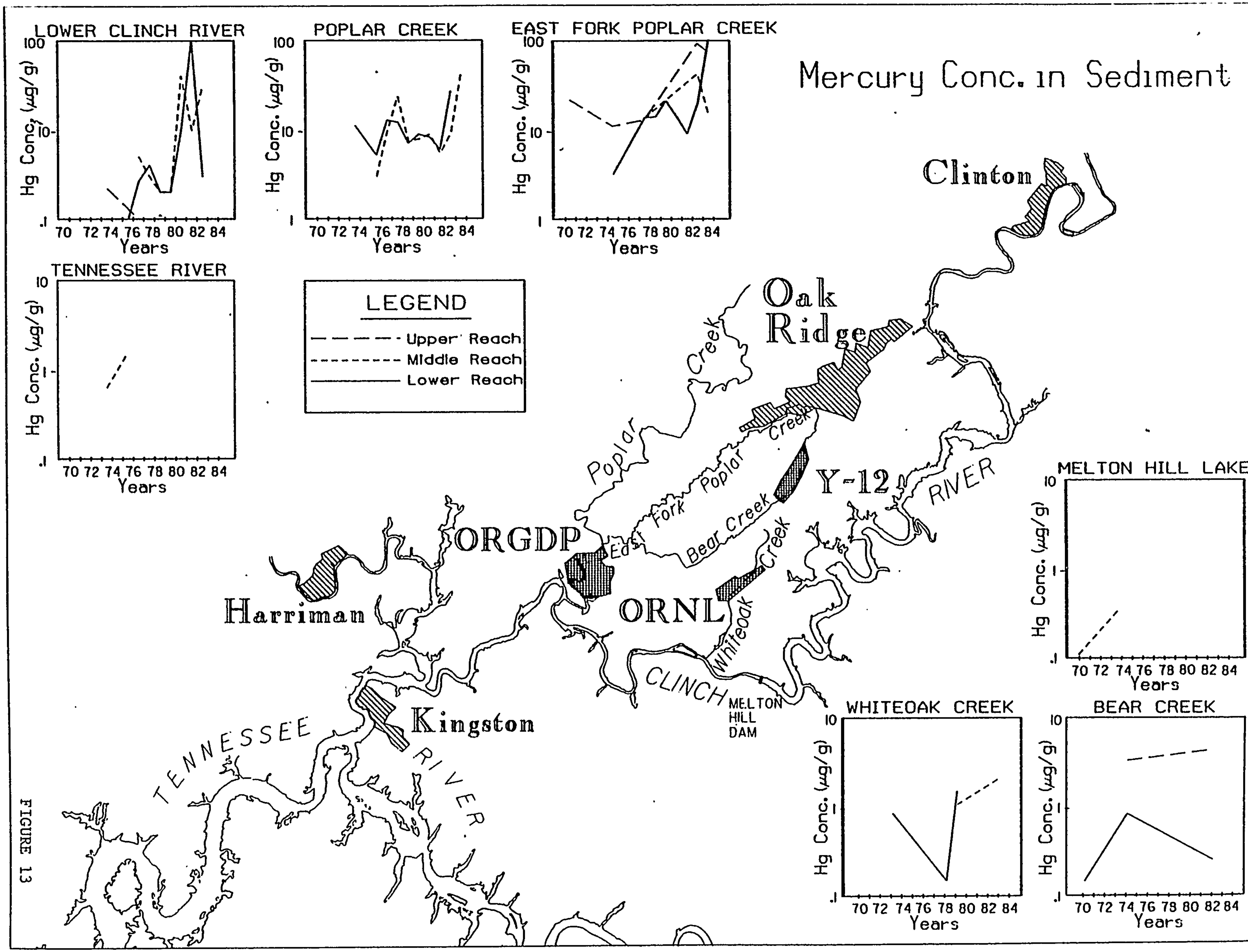
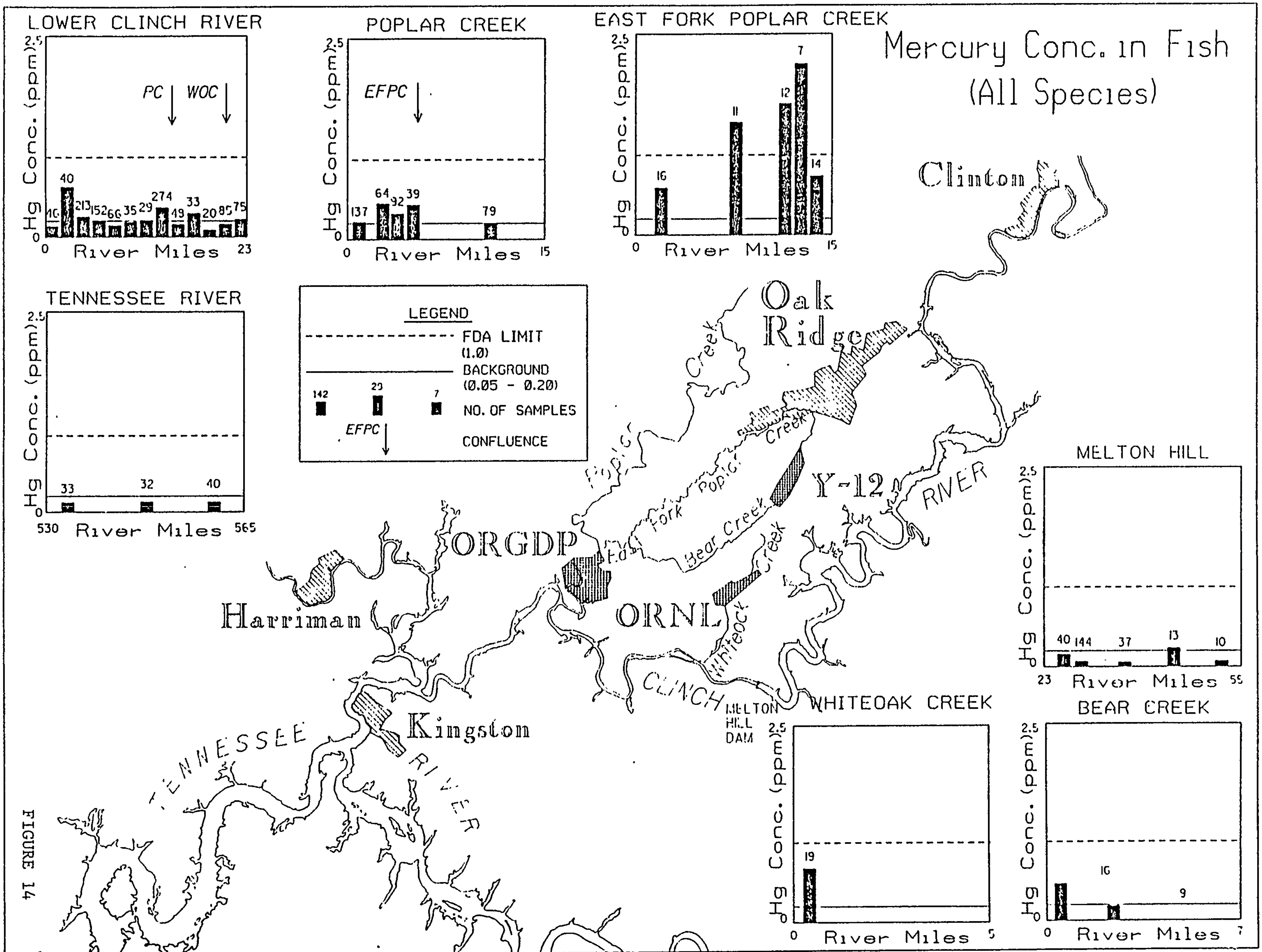


FIGURE 12



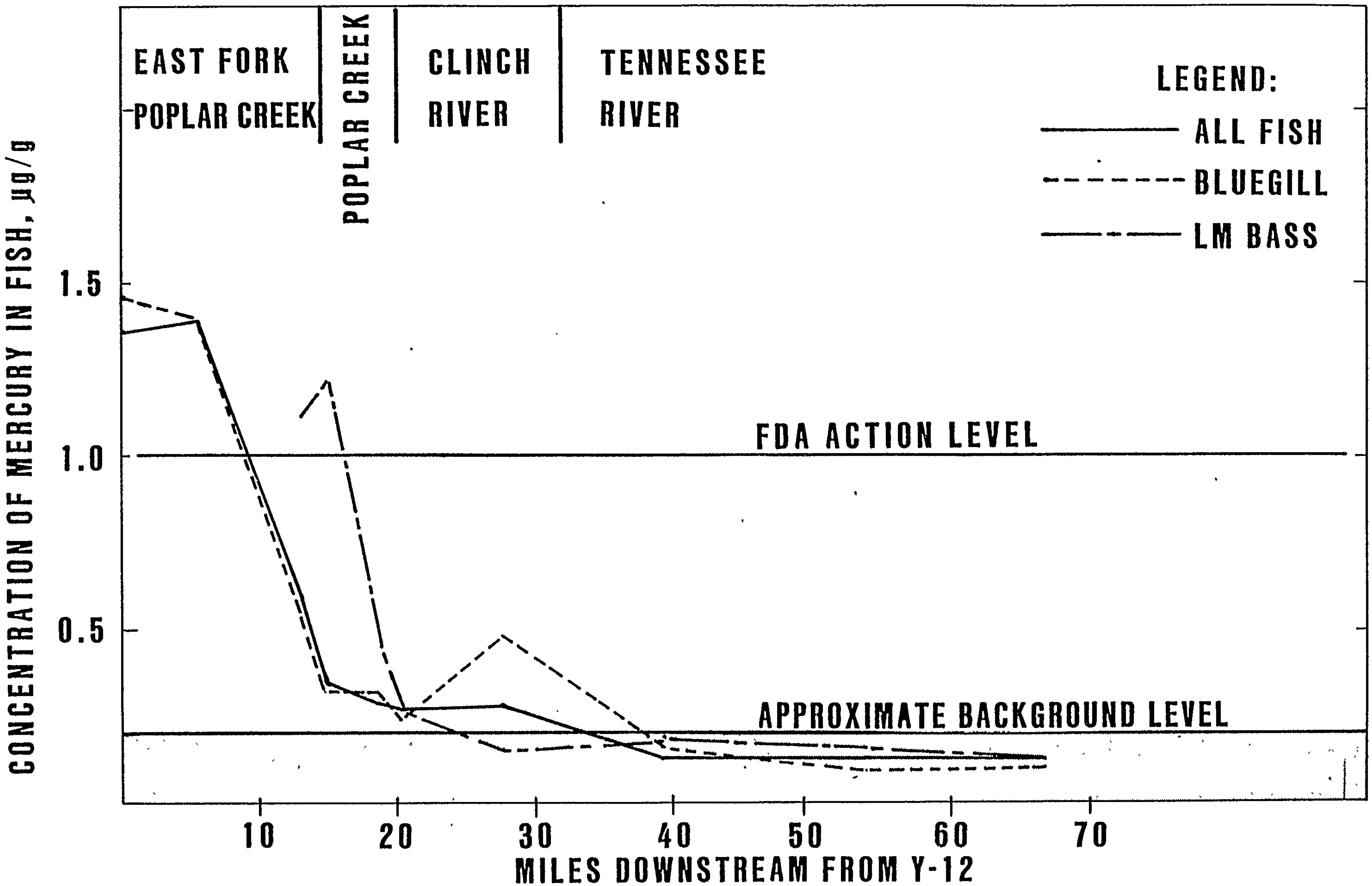
Mercury Conc. in Sediment
LOWER CLINCH RIVER
POPLAR CREEK
EAST FORK POPLAR CREEK
TENNESSEE RIVER
MELTON HILL LAKE
WHITEOAK CREEK
BEAR CREEK
Hg Conc. (μg/g)
Years
70 72 74 76 78 80 82 84
LEGEND
Upper Reach
Middle Reach
Lower Reach
Clinton
Oak Ridge
Y-12
RIVER
Poplar Creek
East Fork Poplar Creek
Bear Creek
Whiteoak Creek
ORGDP
ORNL
CLINCH
MELTON HILL DAM
Harriman
Kingston
TENNESSEE RIVER

FIGURE 13



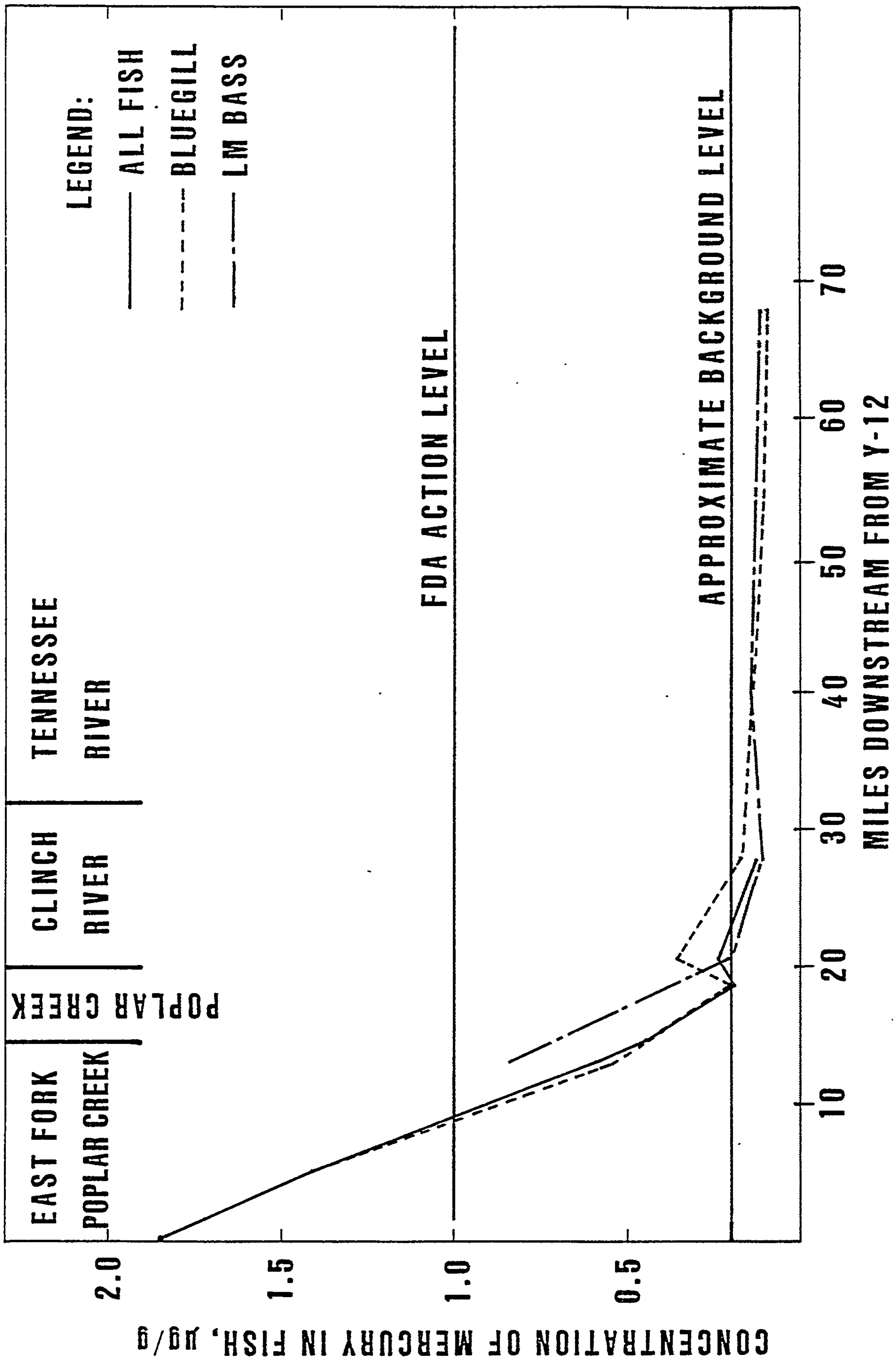
Mercury Conc. in Fish
(All Species)
LOWER CLINCH RIVER
Hg Conc. (ppm)
2.5
0
PC
WOC
40
16
213
152
66
35
29
274
49
33
20
85
75
River Miles
0
23
POPLAR CREEK
Hg Conc. (ppm)
2.5
0
EFPC
137
64
92
39
79
River Miles
0
15
EAST FORK POPLAR CREEK
Hg Conc. (ppm)
2.5
0
16
11
12
7
14
River Miles
0
15
TENNESSEE RIVER
Hg Conc. (ppm)
2.5
0
33
32
40
River Miles
530
565
LEGEND
FDA LIMIT
(1.0)
BACKGROUND
(0.05 - 0.20)
142
29
7
NO. OF SAMPLES
EFPC
CONFLUENCE
Clinton
Oak
Ridge
Creek
Poplar
Creek
East Fork Poplar
Bear Creek
Creek
Whiteock
Y-12
RIVER
ORGDP
ORNL
Harriman
CLINCH
MELTON
HILL
DAM
Kingston
TENNESSEE
RIVER
MELTON HILL
Hg Conc. (ppm)
2.5
0
40
144
37
13
10
River Miles
23
55
WHITEOAK CREEK
Hg Conc. (ppm)
2.5
0
19
River Miles
0
5
BEAR CREEK
Hg Conc. (ppm)
2.5
0
16
9
River Miles
0
7

FIGURE 14



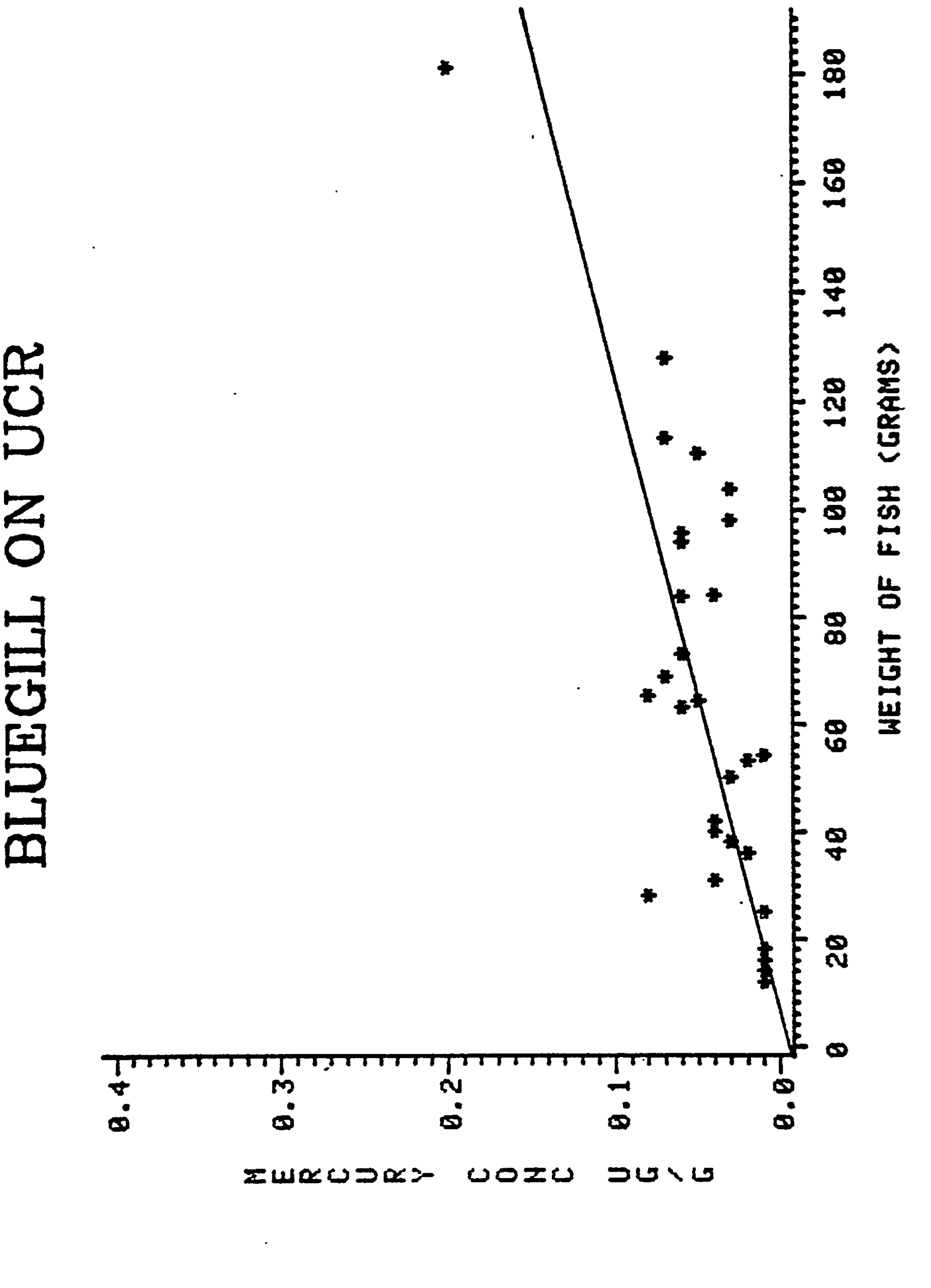
AVERAGE MERCURY CONCENTRATION IN FISH IN STREAM REACHES DOWNSTREAM OF THE Y-12 PLANT (1970-1983)

FIGURE 15



AVERAGE MERCURY CONCENTRATION IN FISH IN STREAM REACHES DOWNSTREAM OF THE Y-12 PLANT (1982-1983)

FIGURE 16



BLUEGILL ON UCR
MERCURY CONC UG/G
0.0
0.1
0.2
0.3
0.4
WEIGHT OF FISH (GRAMS)
0
20
40
60
80
100
120
140
160
180

FIGURE 17

LM BASS ON UCR

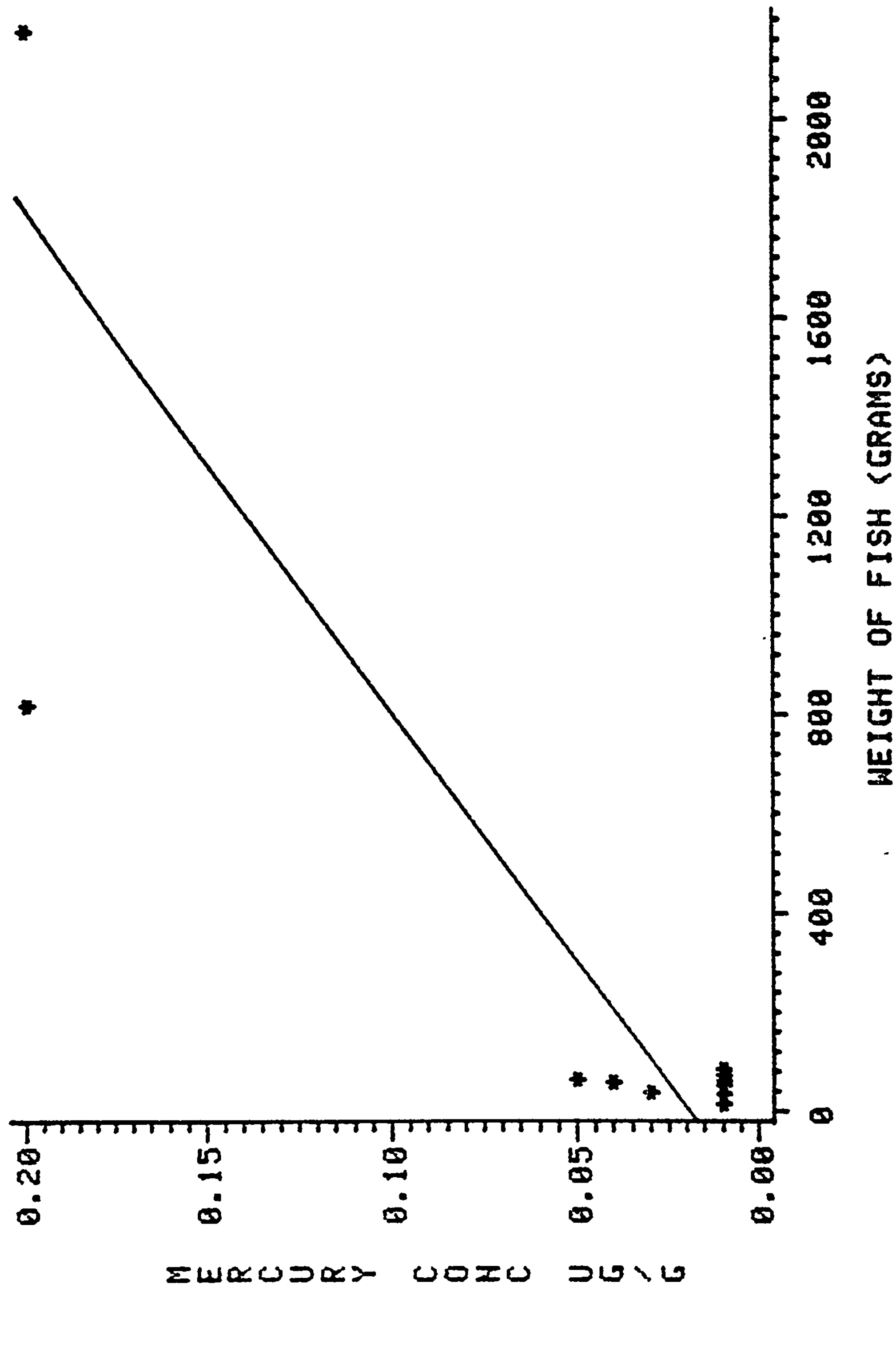


FIGURE 18

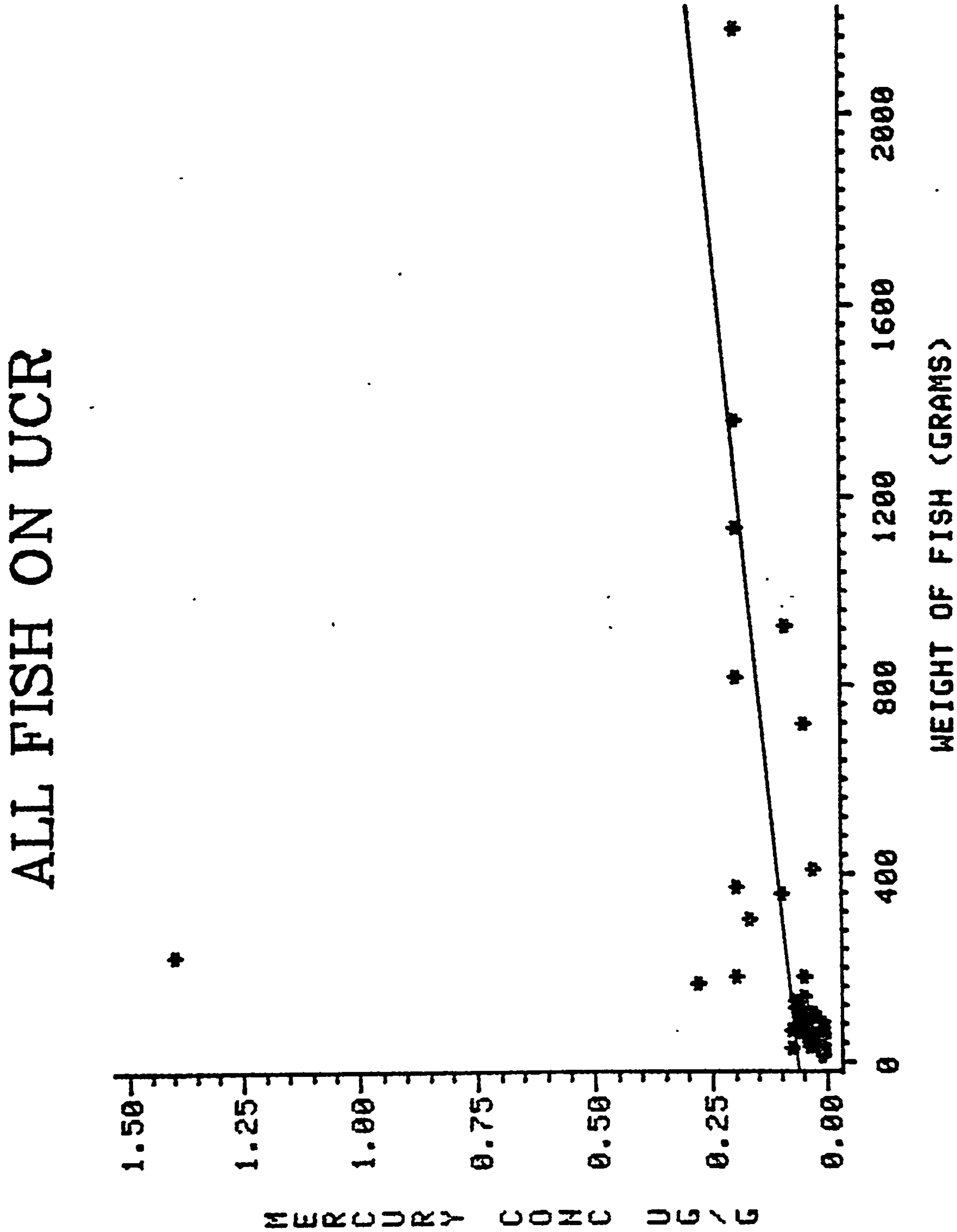

ALL FISH ON UCR
MERCURY CONC UG/G
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
400
800
1200
1600
2000
WEIGHT OF FISH (GRAMS)

FIGURE 19

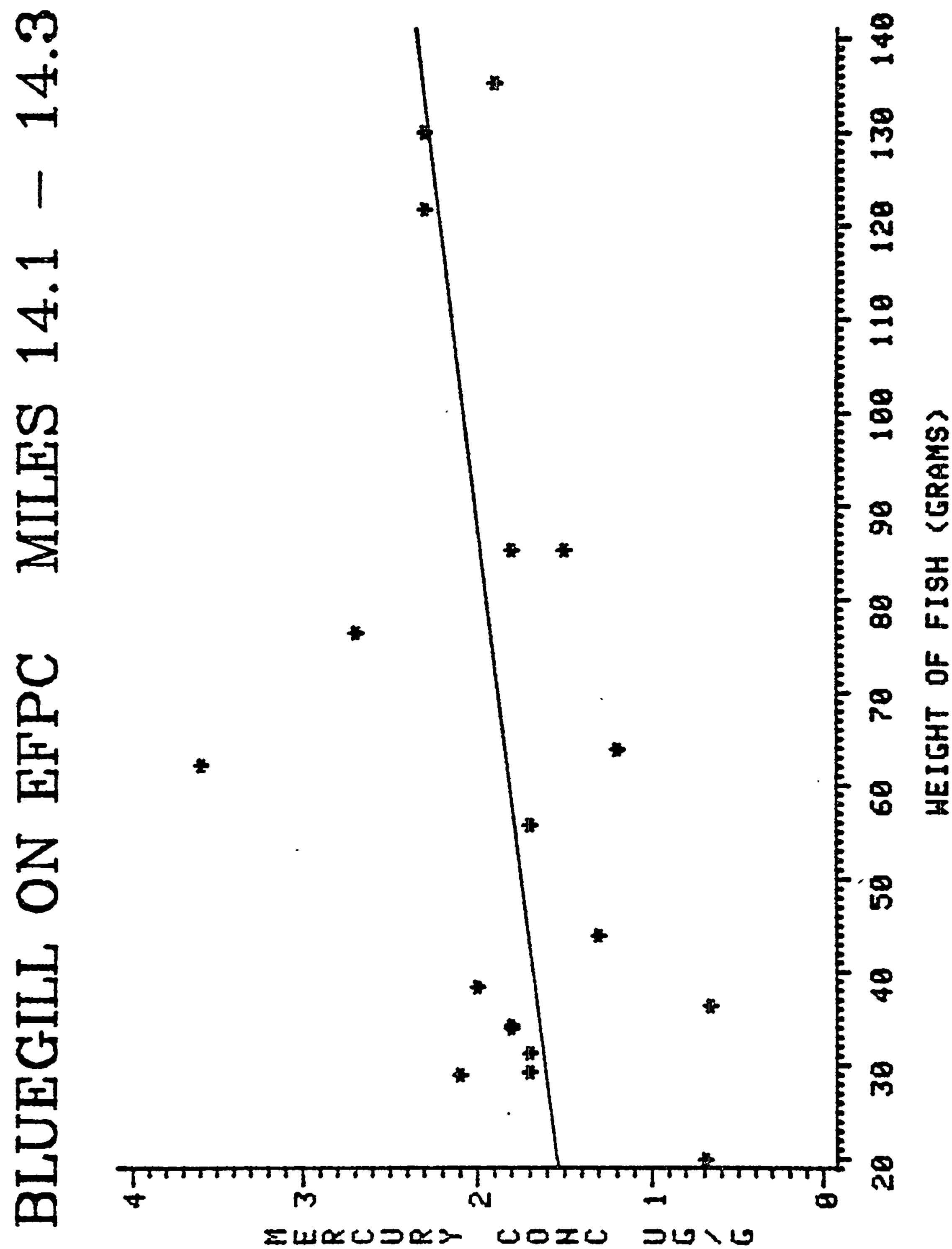
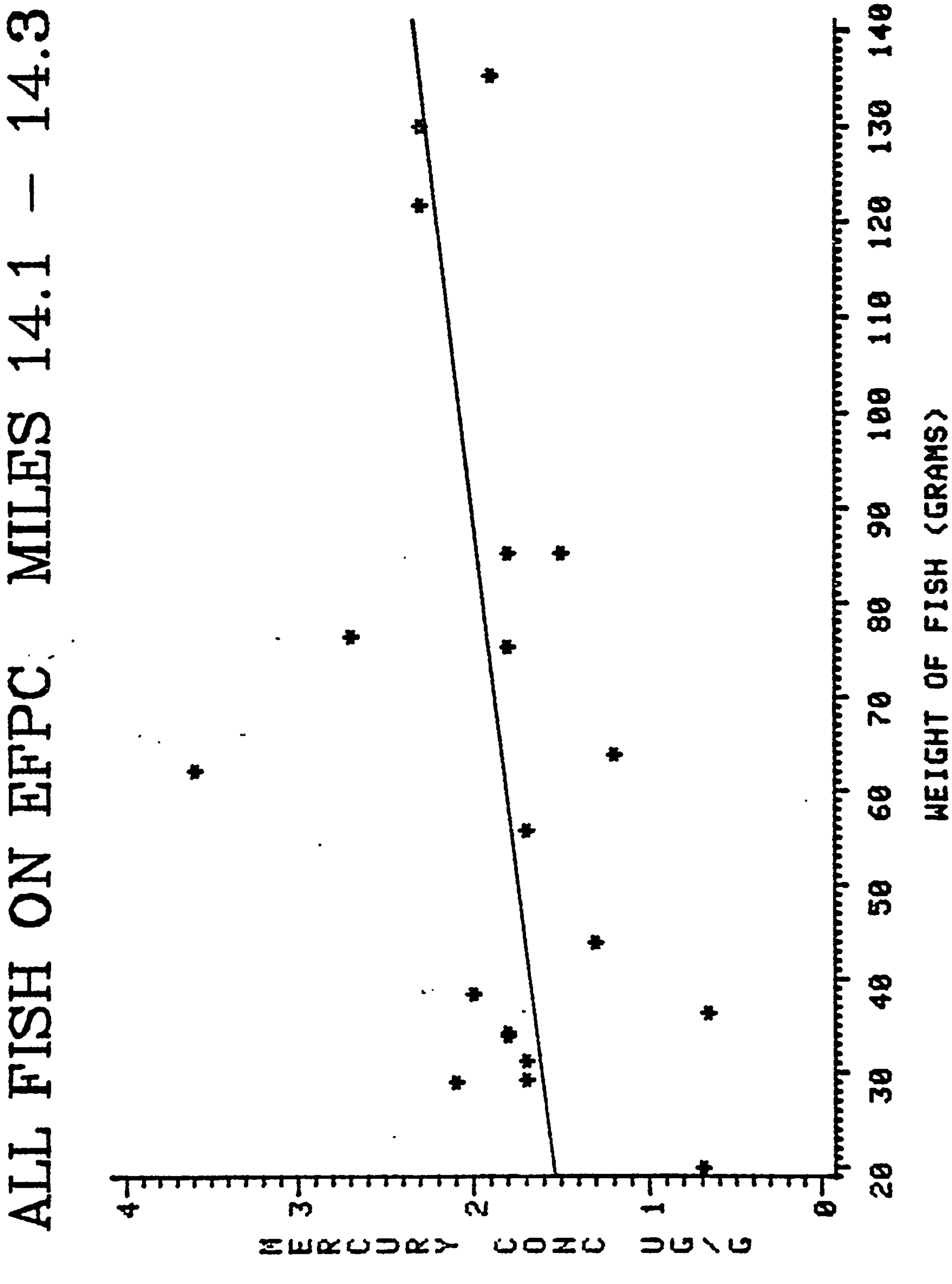

BLUEGILL ON EFPC MILES 14.1 — 14.3
MERCURY CONC UG/G
0
1
2
3
4
WEIGHT OF FISH (GRAMS)
20
30
40
50
60
70
80
90
100
110
120
130
140

FIGURE 20



ALL FISH ON EFPC MILES 14.1 — 14.3
MERCURY CONC UG/G
WEIGHT OF FISH (GRAMS)
0
1
2
3
4
20
30
40
50
60
70
80
90
100
110
120
130
140

FIGURE 21

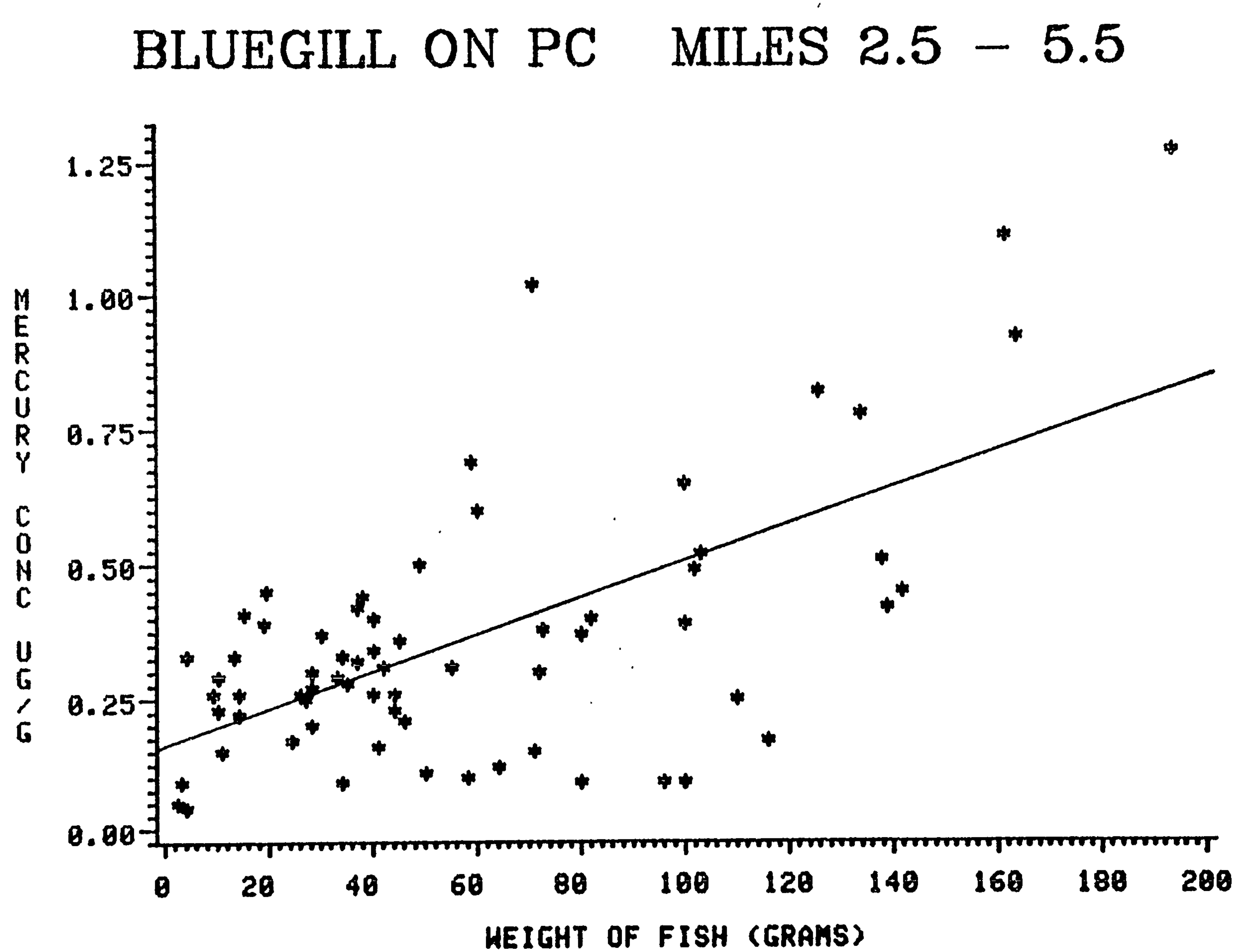
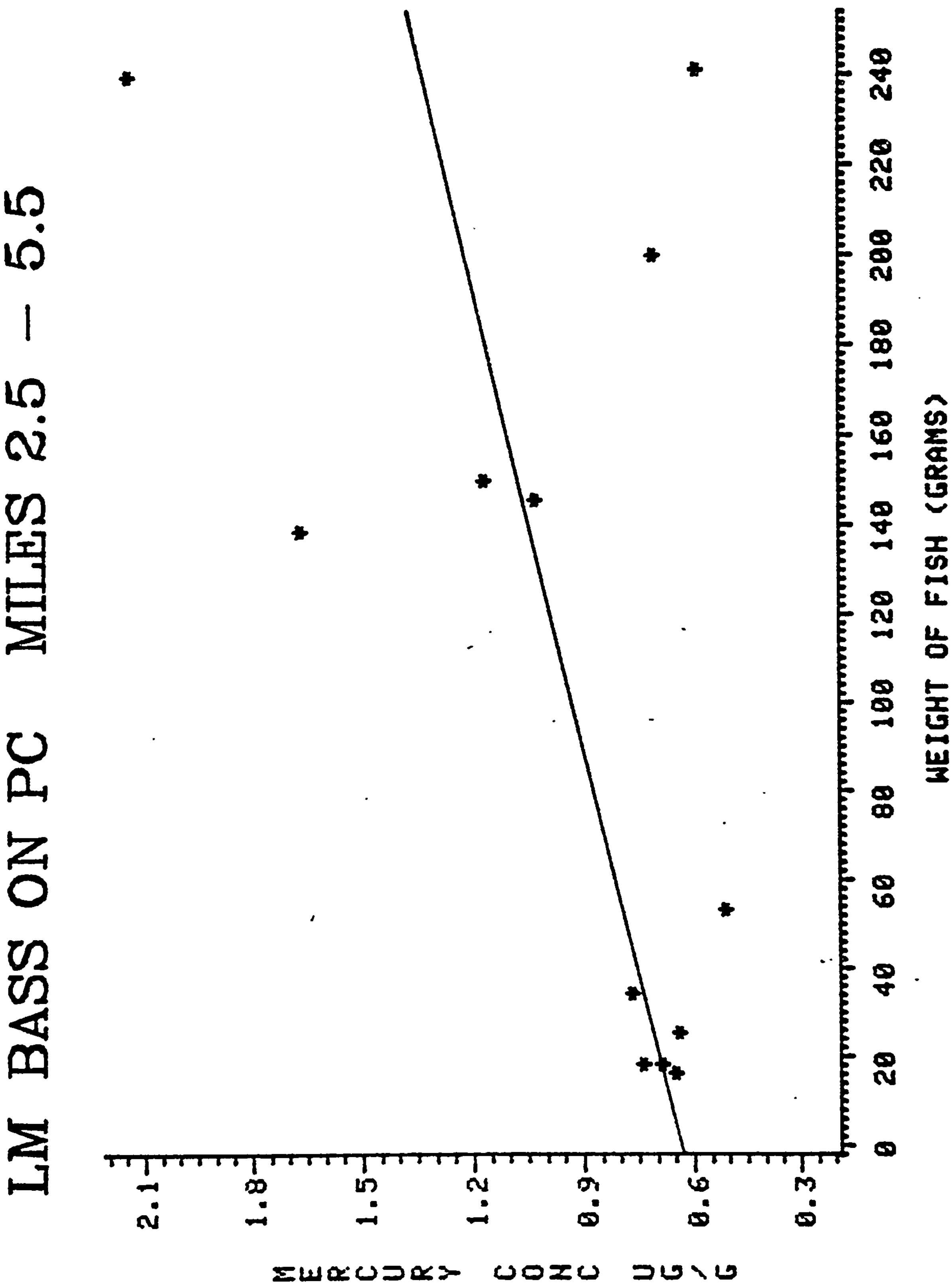

BLUEGILL ON PC MILES 2.5 – 5.5
MERCURY CONC UG/G
1.25
1.00
0.75
0.50
0.25
0.00
0
20
40
60
80
100
120
140
160
180
200
WEIGHT OF FISH (GRAMS)

FIGURE 22



LM BASS ON PC MILES 2.5 — 5.5
MERCURY CONC UG/G
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
20
40
60
80
100
120
140
160
180
200
220
240
WEIGHT OF FISH (GRAMS)

FIGURE 23

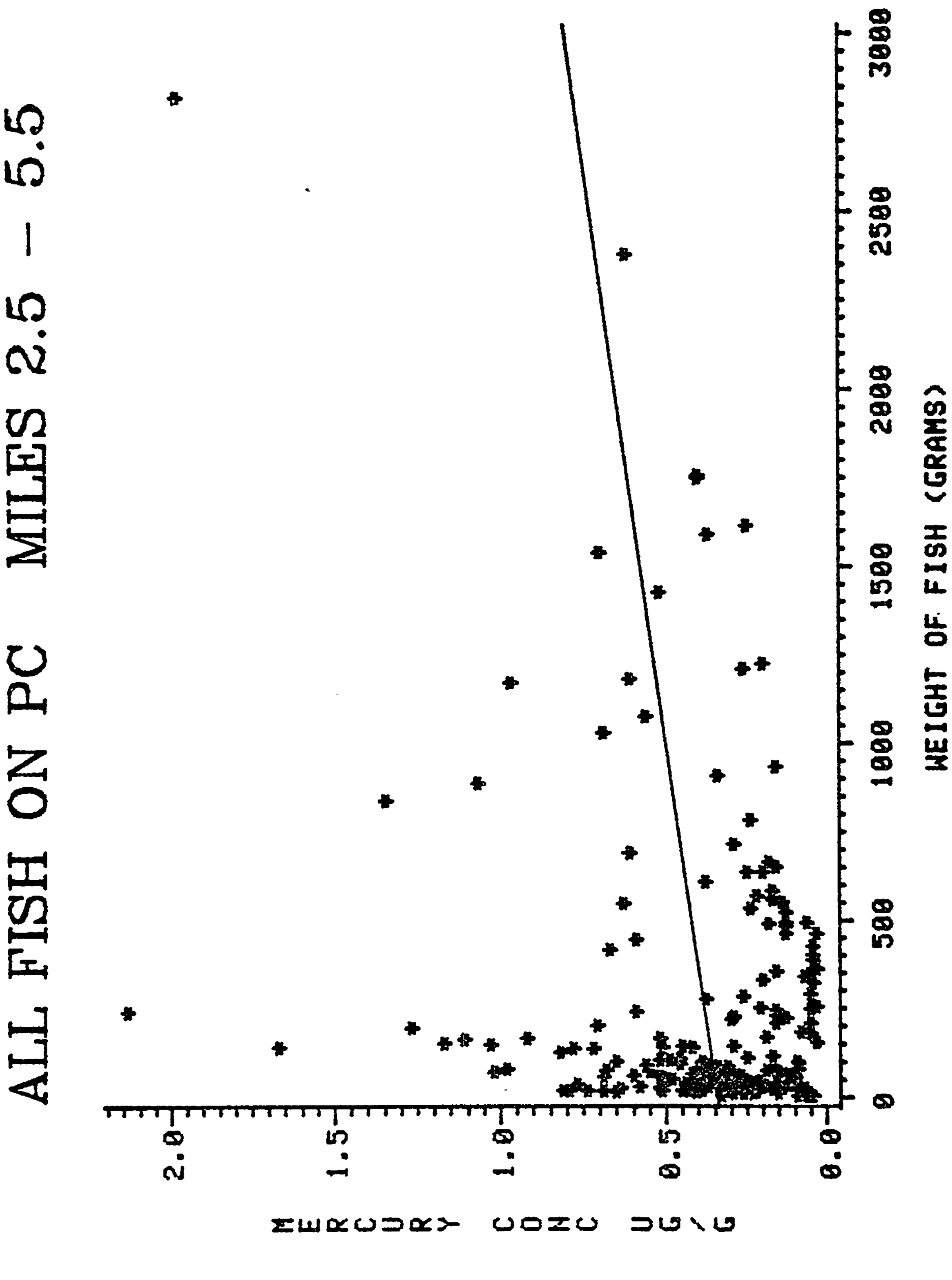
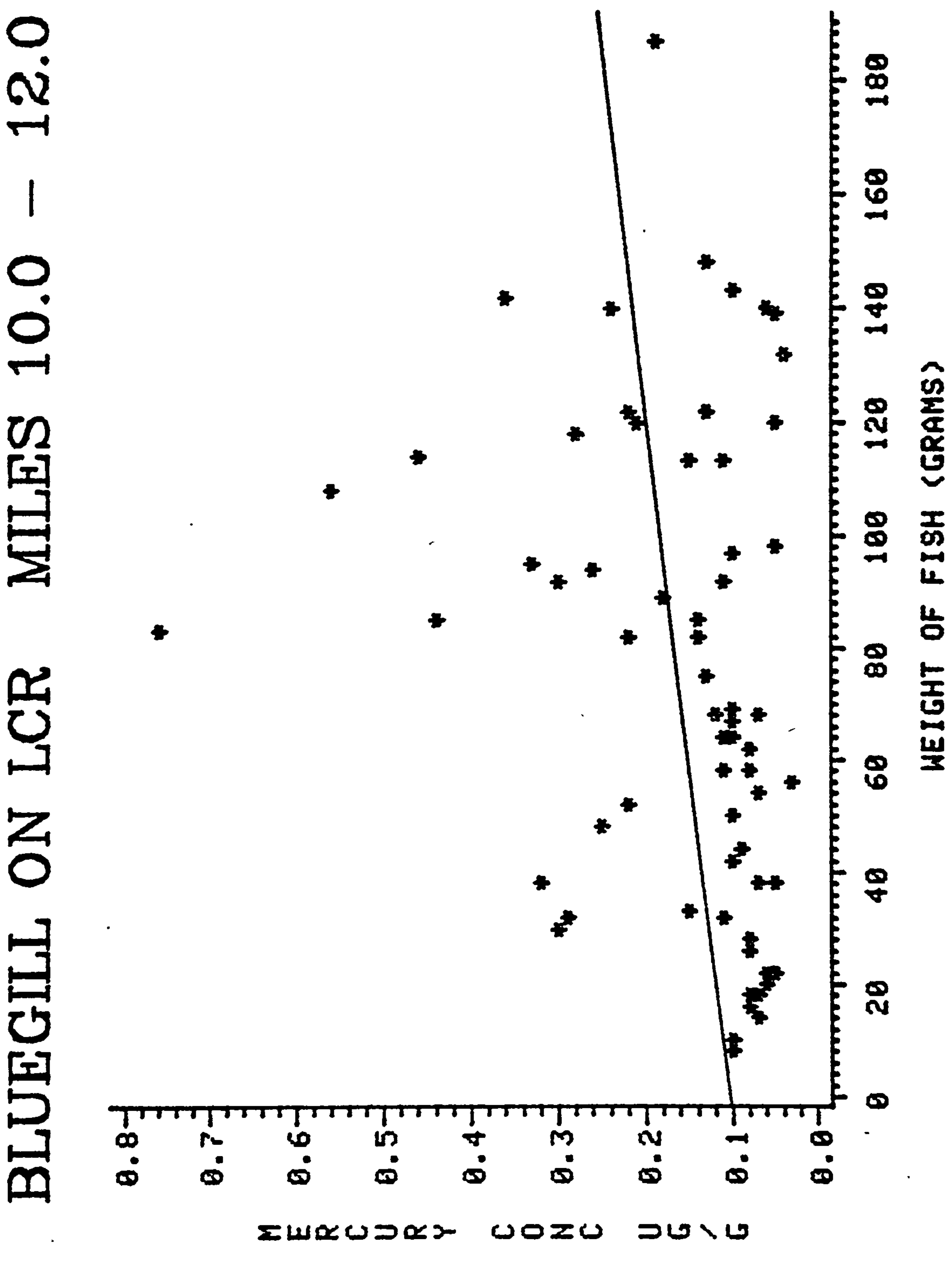

ALL FISH ON PC MILES 2.5 – 5.5
MERCURY CONC UG/G
0.0
0.5
1.0
1.5
2.0
WEIGHT OF FISH (GRAMS)
0
500
1000
1500
2000
2500
3000

FIGURE 24



BLUEGILL ON LCR MILES 10.0 — 12.0
MERCURY CONC UG/G
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100
120
140
160
180
WEIGHT OF FISH (GRAMS)

FIGURE 25

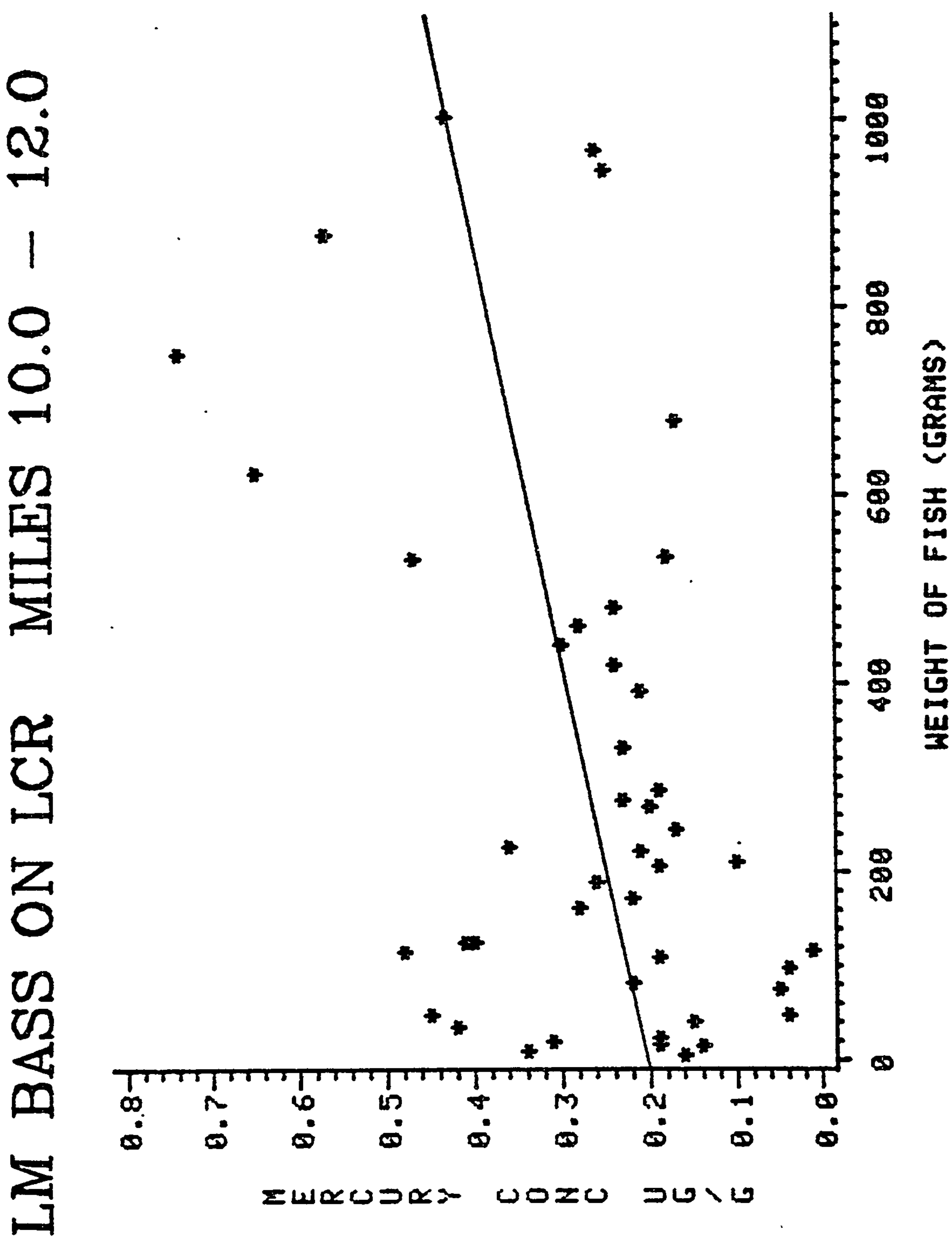

LM BASS ON LCR MILES 10.0 — 12.0
MERCURY CONC UG/G
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
200
400
600
800
1000
WEIGHT OF FISH (GRAMS)

FIGURE 26

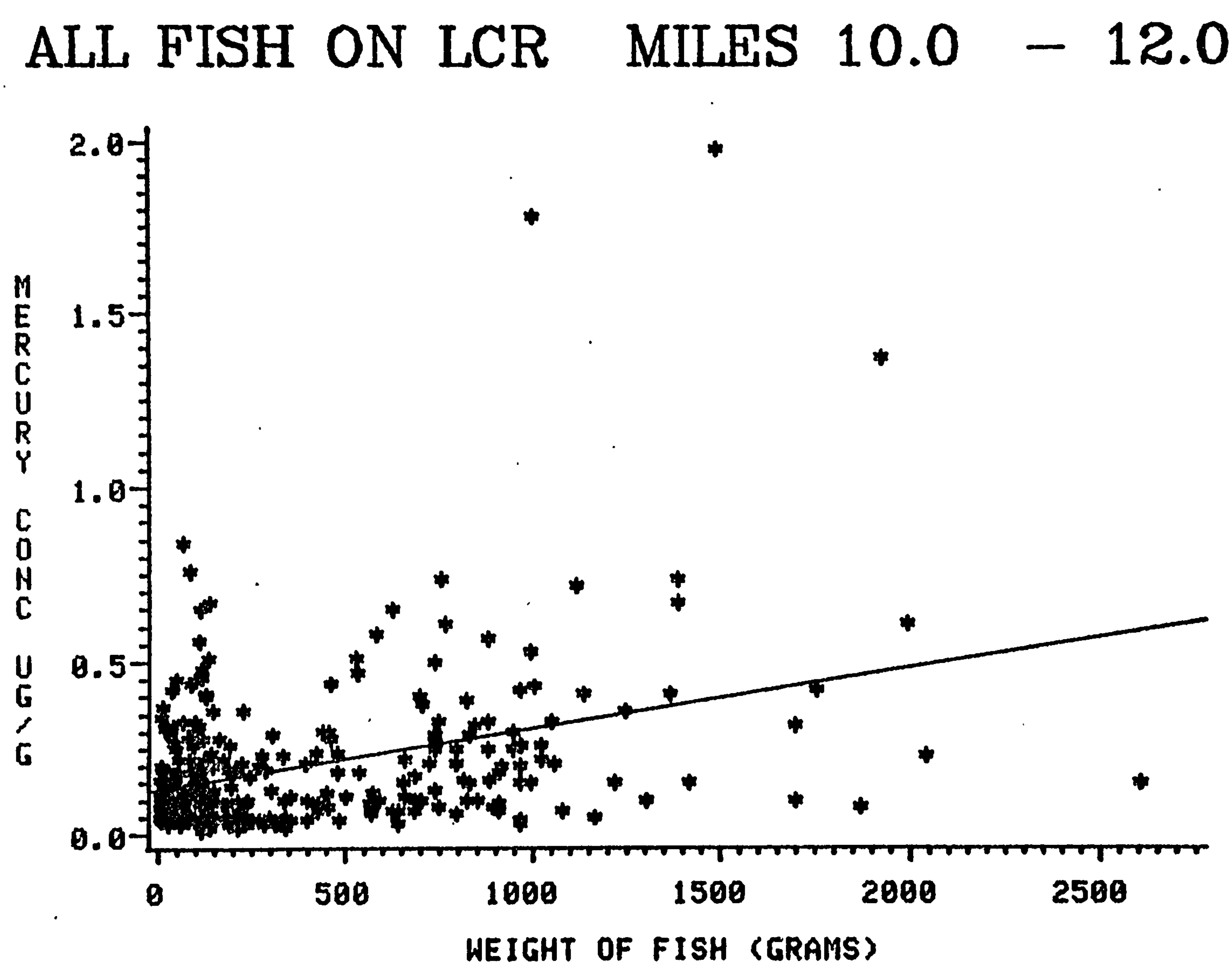

ALL FISH ON LCR MILES 10.0 — 12.0
MERCURY CONC UG/G
2.0
1.5
1.0
0.5
0.0
0
500
1000
1500
2000
2500
WEIGHT OF FISH (GRAMS)

FIGURE 27

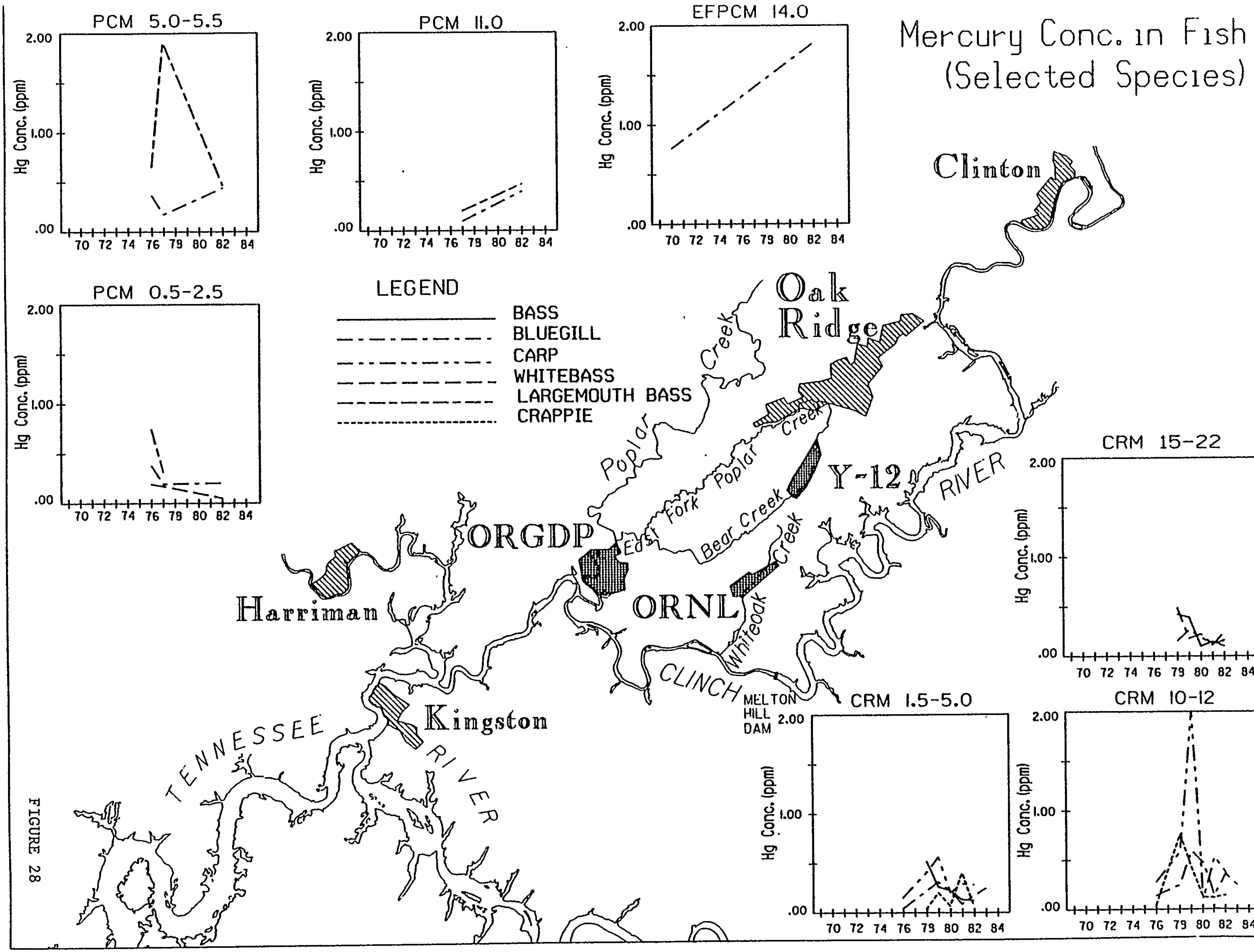
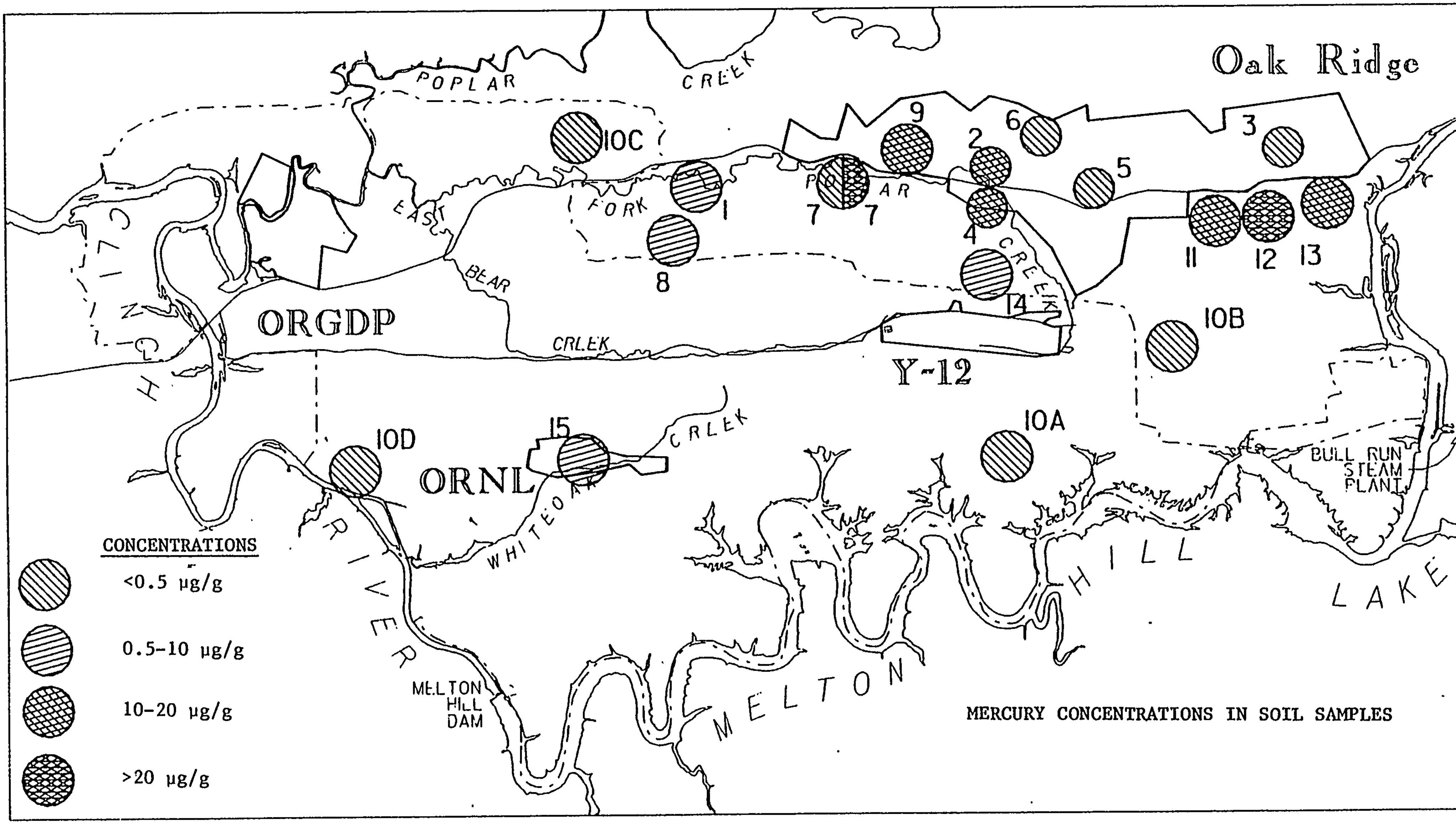

Mercury Conc. in Fish
(Selected Species)
PCM 5.0-5.5
PCM 11.0
EFPCM 14.0
PCM 0.5-2.5
CRM 15-22
CRM 1.5-5.0
CRM 10-12
Hg Conc. (ppm)
2.00
1.00
.00
70 72 74 76 78 80 82 84
LEGEND
BASS
BLUEGILL
CARP
WHITEBASS
LARGEMOUTH BASS
CRAPPIE
Clinton
Oak
Ridge
Poplar Creek
East Fork Poplar Creek
Bear Creek
Whiteoak Creek
Y-12
RIVER
ORGDP
ORNL
Harriman
CLINCH
MELTON
HILL
DAM
Kingston
TENNESSEE
RIVER

FIGURE 28



MERCURY CONCENTRATIONS IN SOIL SAMPLES

FIGURE 29

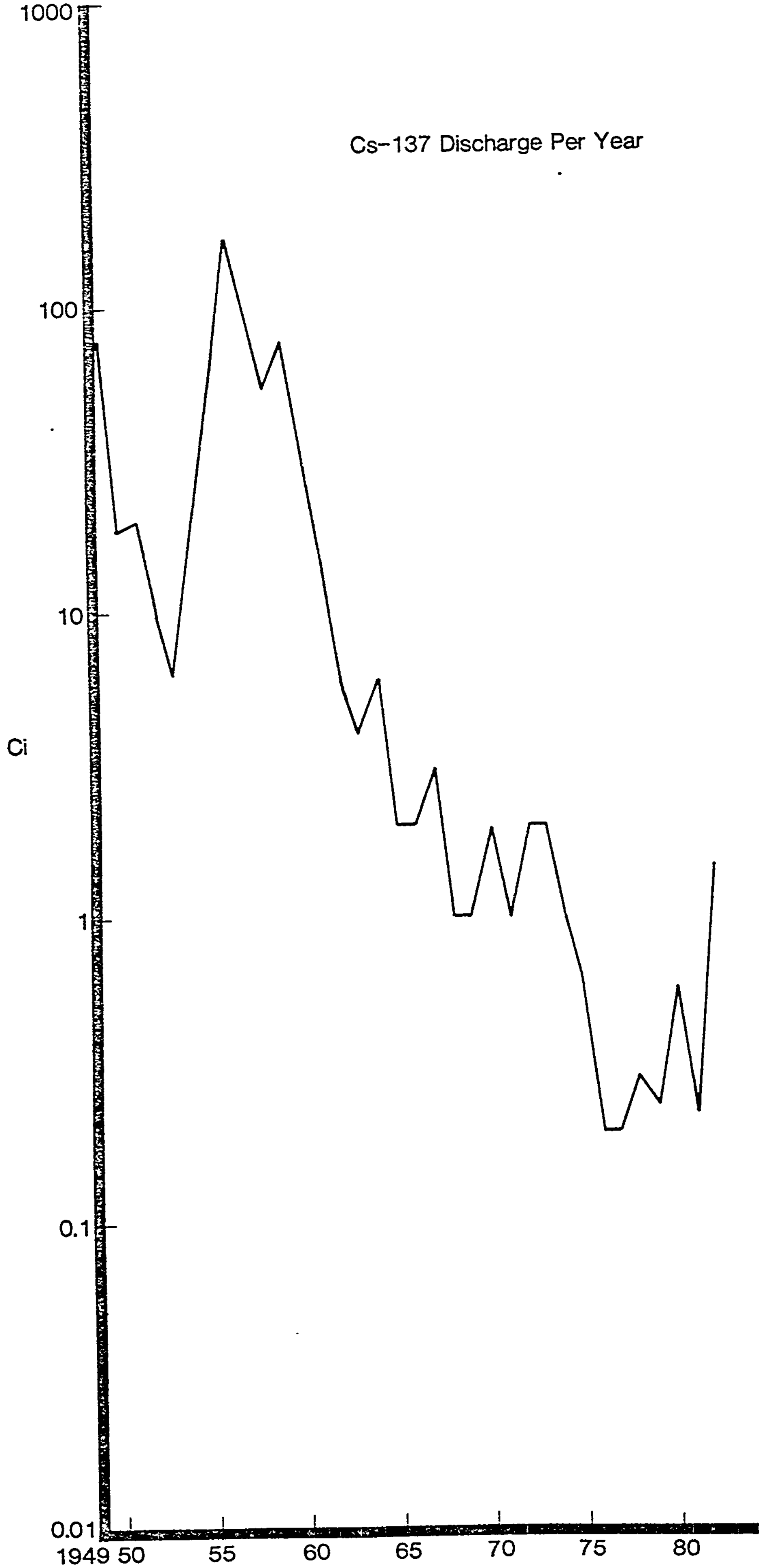
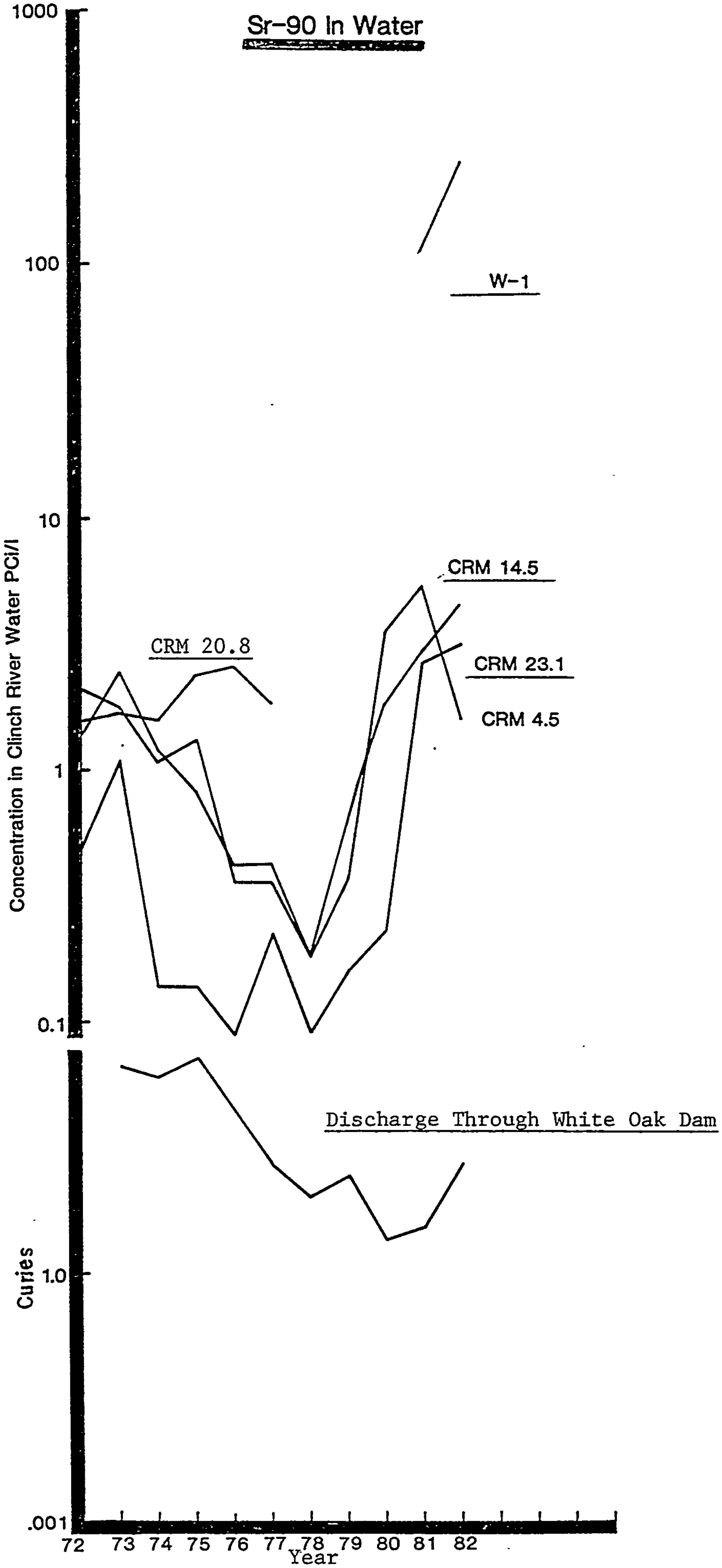
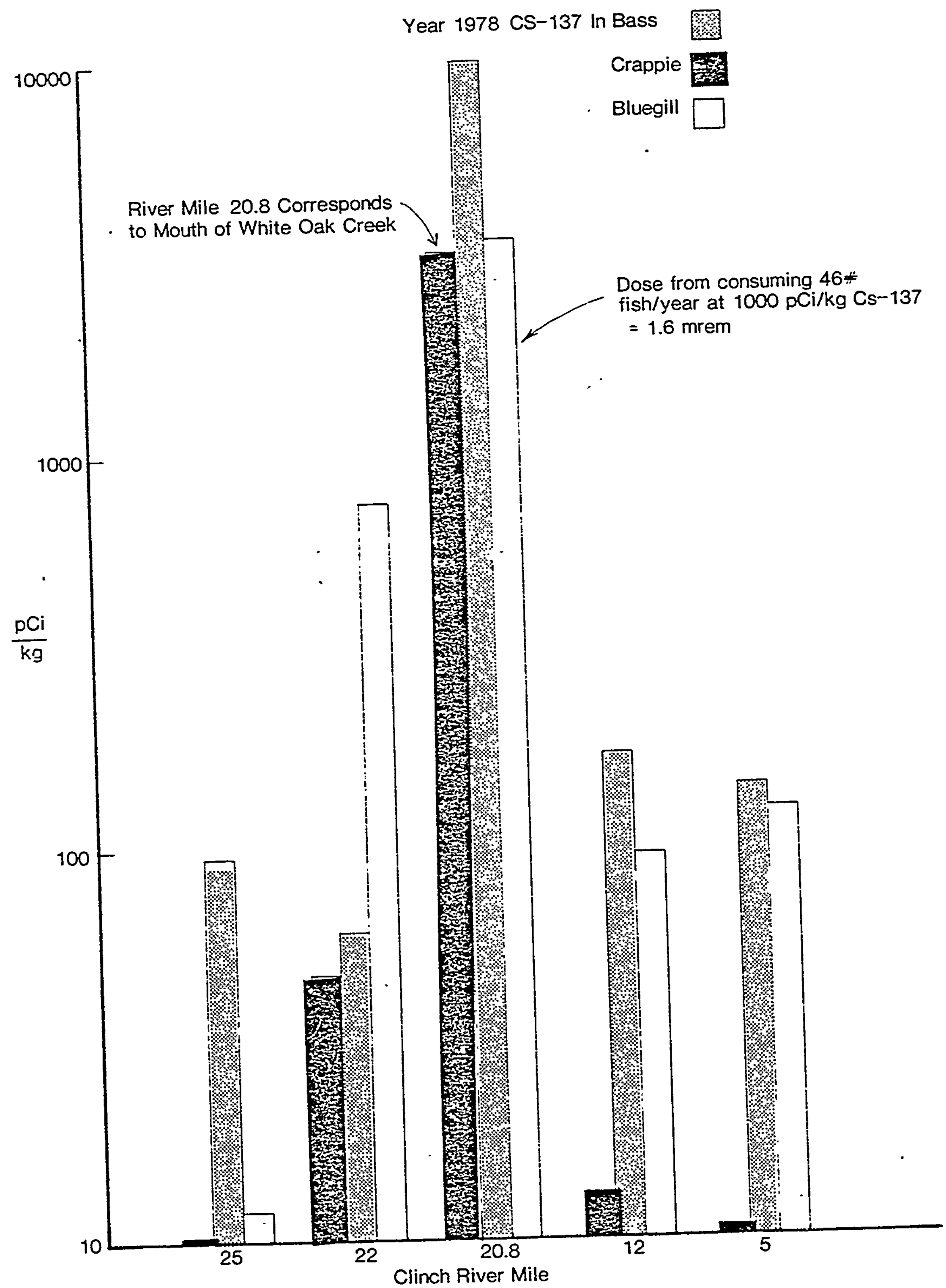

Cs-137 Discharge Per Year
1000
100
10
1
0.1
0.01
Ci
1949 50
55
60
65
70
75
80

FIGURE 30



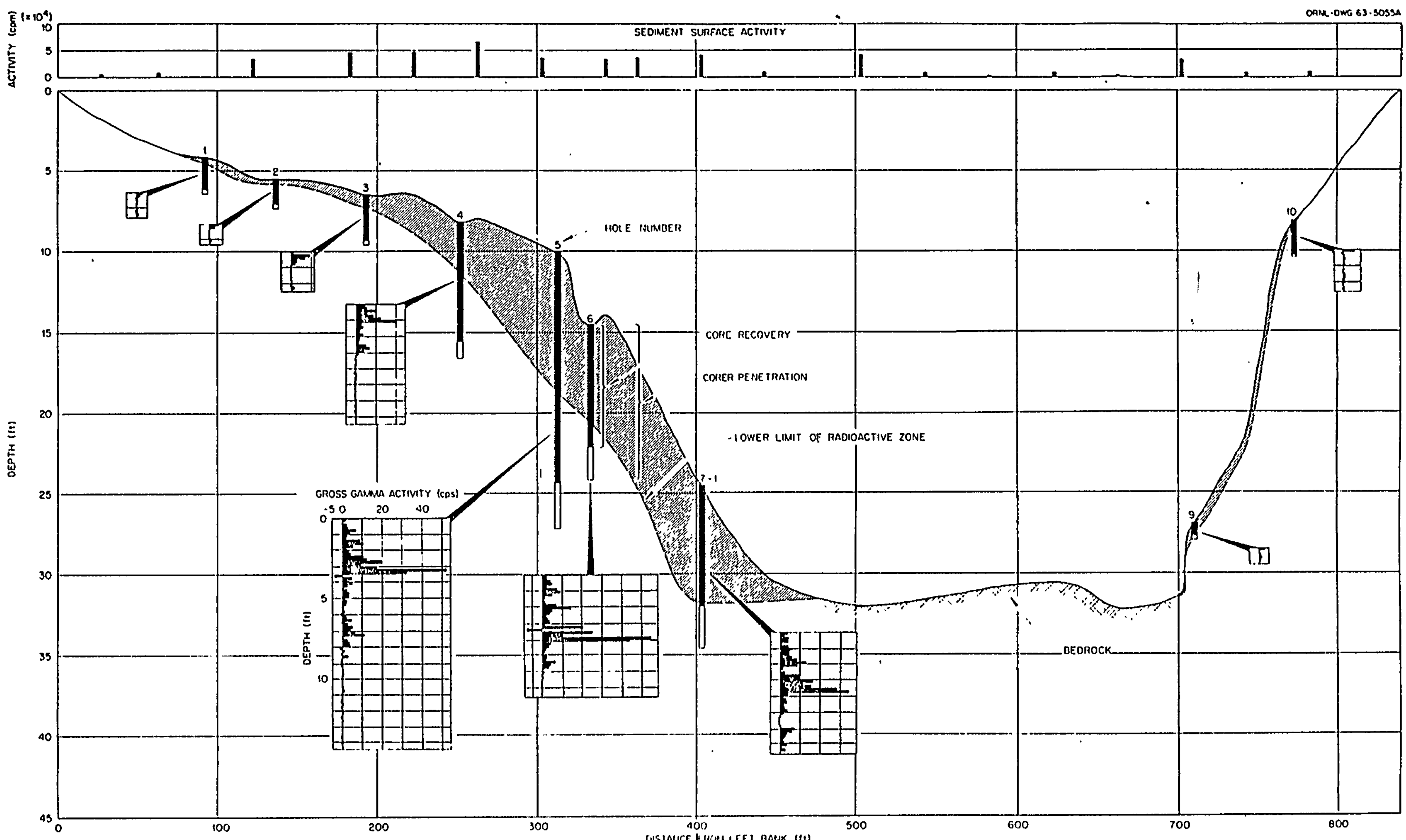
REVISED
FIGURE 31



Year 1978 CS-137 In Bass
Crappie
Bluegill
10000
1000
100
10
pCi/kg
River Mile 20.8 Corresponds to Mouth of White Oak Creek
Dose from consuming 46# fish/year at 1000 pCi/kg Cs-137 = 1.6 mrem
25
22
20.8
12
5
Clinch River Mile

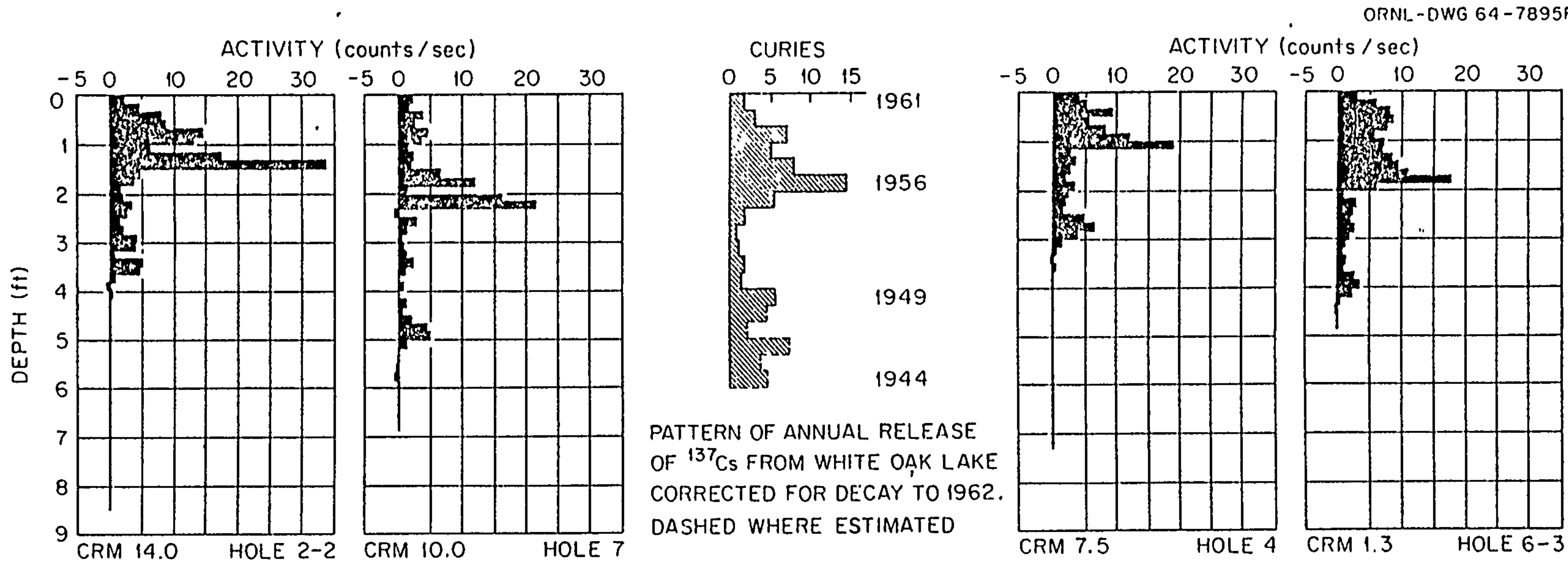
FIGURE 32

7



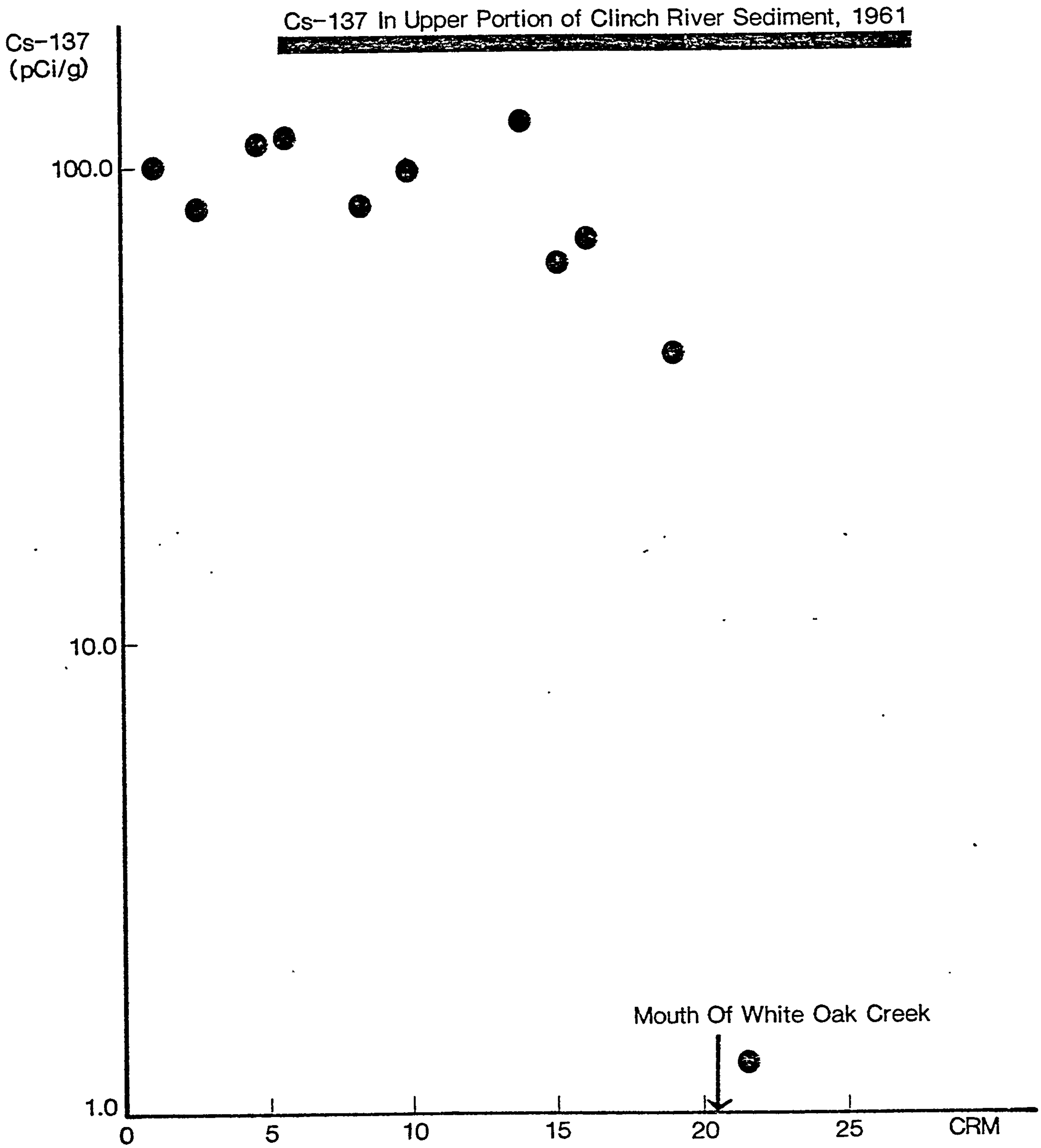
Section at CRM 7.5 Showing Penetration, Recovery, and Gross Gamma Radioactivity Variation with Depth for 1962 Bottom Sediment Core Samples (Vertical Exaggeration 10:1)

FIGURE 33



Comparison of Patterns of Variation with Depth of Gross Gamma Radioactivity in Four Bottom Sediment Cores to Variations in Annual Releases of 137 Cs to Clinch River

FIGURE 34



Cs-137 In Upper Portion of Clinch River Sediment, 1961
Cs-137
(pCi/g)
100.0
10.0
1.0
0
5
10
15
20
25
CRM
Mouth Of White Oak Creek

FIGURE 35

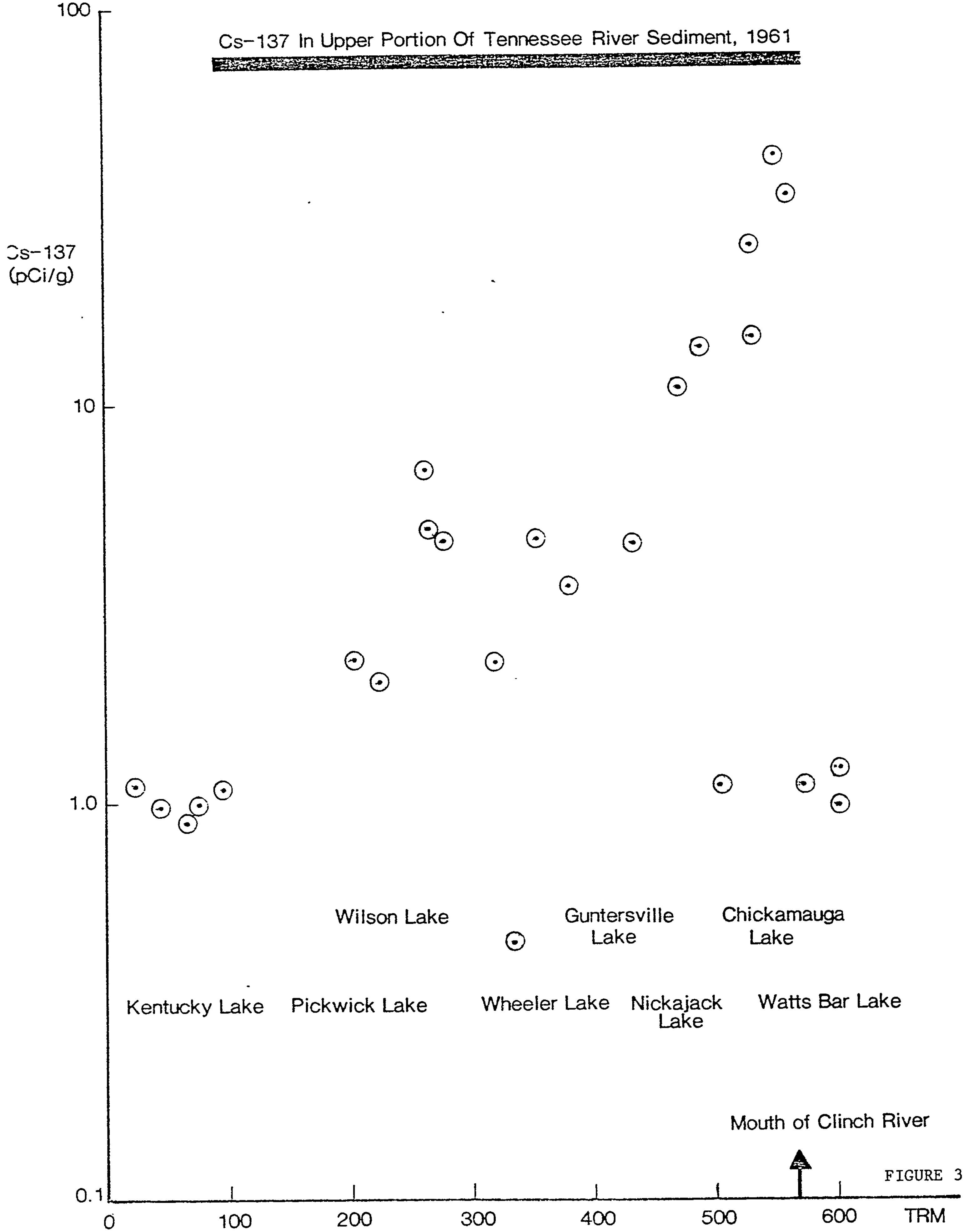
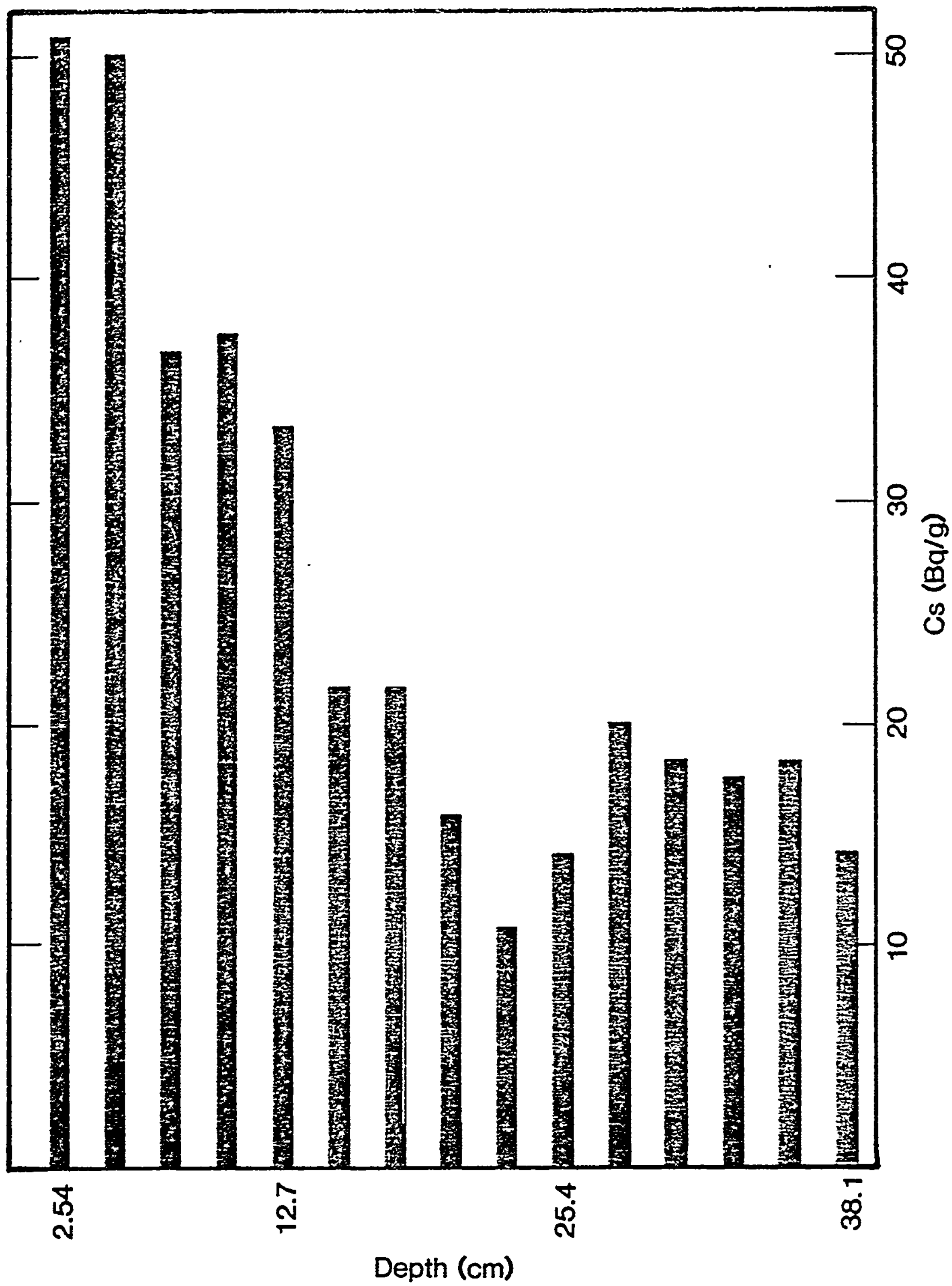

Cs-137 In Upper Portion Of Tennessee River Sediment, 1961
Cs-137
(pCi/g)
100
10
1.0
0.1
Wilson Lake
Guntersville
Lake
Chickamauga
Lake
Kentucky Lake
Pickwick Lake
Wheeler Lake
Nickajack
Lake
Watts Bar Lake
Mouth of Clinch River
0
100
200
300
400
500
600
TRM

FIGURE 36



Cesium-137 Content (Bq/g) In White Oak Creek Sediment, 1978 Sampling Program

FIGURE 37

Appendix II - Tables

SOURCES OF DATA

OAK RIDGE OPERATIONS

OAK RIDGE NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION AGENCY

U. S. GEOLOGICAL SURVEY

STATE OF TENNESSEE

TENNESSEE VALLEY AUTHORITY

TABLE 1

SUMMARY OF AVAILABLE DATA

1. DOE data submitted to TVA by letter of June 14, 1983 from J. F. Wing (see attached list).

2. State of Tennessee data for 1977-78 fish from lower Clinch River submitted to TVA in July 13, 1983 letter from David Melgoard.

3. Data presented by Joe LaGrone in testimony at the July 11, 1983 Congressional hearing.

4. TVA fish data collected in June 1983 from the lower Clinch River and Watts Bar Reservoir.

5. STORET data on water and sediment collected by TVA, EPA, TNWQCD, and USGS (STORET station codes: 475775, 475780, 475115, 476031, 475784, 475325, 476032, 475639, 475638, 475776, 476105, 476012, 510213, 510174, 475910, 03538000, 03535912, 03538160, 000680, and 019002).

6. TVA 1976 study of sediment in the vicinity of the Clinch River Breeder Reactor Project.

7. Recent (June 16-July 31) DOE data on mercury concentrations in soil, sediment, water, and vegetables in the Oak Ridge area.

8. TVA Division of Occupational Health and Safety, "Update of Preconstruction Radioactivity Levels in the Vicinity of the Proposed Clinch River Breeder Reactor Project," August 1981.

9. Oakes, T. W.; Kelly, B. A.; Ohnesorge, W. F.; Eldridge, J. S.; Bird, J. C.; Shank, K. E.; Tsakeres, F. S.; <u>Technical Background Information for the Environmental and Safety Report, Vol 4: White Oak Lake and Dam</u>, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161, March 1982.

10. Oakes, T. W.; Ohnesorge, W. F.; Eldridge, J. S.; Scott, T. G.; Parsons, D. W.; Hubbard, H. M.; Sealand, O. M.; Shank, K. E.; Eyman, L. D.; <u>Technical Background Information for the Environmental and Safety Report, Vol. 5: The 1977 Clinch River Sediment Survey - Data Presentation</u>; National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

11. Oakes, T. W.; Shank, K. E.; <u>Radioactive Waste Disposal Areas and Associated Environmental Surveillance Data at Oak Ridge National Laboratory</u>, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161.

12. Y-12 Plant Site Oak Ridge, Tennessee, <u>Environmental Assessment</u>, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161, December 1982.

TABLE 2

PARAMETERS EXAMINED

WATER/SEDIMENT/FISH	WATER ONLY	RADIOLOGICAL
MERCURY	IRON	CESIUM
CADMIUM	CYANIDE	PLUTONIUM
CHROMIUM	HARDNESS	STRONTIUM
COPPER	BOD	THORIUM
LEAD	COD	URANIUM
NICKEL	TDS	
ZINC	NO_x	
PCB		
ALUMINUM		
BERYLLIUM		
MANGANESE		

TABLE 3

NUMBER OF SAMPLES

PARAMETER	FISH	SEDIMENT	WATER
MERCURY	1991[a]	195	280
CADMIUM	388[b]	103	233
CHROMIUM	391[b]	132	273
COPPER	391[b]	128	181
LEAD	392[b]	122	225
NICKEL	391[b]	131	148
ZINC	391[b]	129	222
PCB	325[b]	33	—
ALUMINUM	—	122	—
BERYLLIUM	—	17	43
MANGANESE	—	120	227
TOXIC ORGANICS	—	—	—

[a] Data for 44 species (522 bluegill, 214 carp samples, 155 largemouth bass, 116 gizzard shad).

[b] Data for 17 species (96 gizzard shad, 68 bluegill, 64 white bass, 33 largemouth bass), primarily from 357 ORNL samples collected in 1977 from Poplar Creek and the lower Clinch River.

TABLE 4

TABLE 5

COMPARISON OF MEAN VALUES FOR VARIOUS CHEMICAL PARAMETERS IN WATER[a]

Parameter	East Fork Poplar Creek[b] 15-10	10-5	5-0	Poplar Creek 6-3	3-0	Lower Clinch River 12-2	Tennessee River 565-530	Bear Creek 8-0	White Oak Creek 2-0	Clinch River and Its Tributaries[c]
Mercury (μg/L)	<0.85	0.70	-	<12.0	<1.1	0.43	<0.20	<0.18	<0.55	<0.23
Cadmium (μg/L)	<3.2	-	-	<4.1	<3.8	<2.32	-	<3.0	<1.0	<0.37
Chromium (μg/L)	55.0	17.0	-	<8.0	<10.7	4.79	-	-	<31.3	<3.07
Copper (μg/L)	-	-	-	-	30.0	6.05	-	-	<16.7	<20.0
Lead (μg/L)	<14.0	-	-	<14.0	<12.7	11.2	-	-	<10.2	4.96
Nickel (μg/L)	-	-	-	<23.8	<20.0	20.9	-	-	<50.0	<54.0
Zinc (μg/L)	<55.0	-	-	44.0	52.7	32.8	30.7	<31.0	28.4	84.4
PCB (μg/L)	-	-	-	-	-	-	-	-	-	-
Aluminum (μg/L)	-	-	-	-	-	-	-	-	-	892
Beryllium (μg/L)	-	-	-	-	<0.10	<10.0	<10.0	-	<10.0	<10.0
Manganese (μg/L)	-	-	-	-	200	71.1	57.5	-	280	105[d]
Iron (μg/L)	-	-	-	-	5900	543	431	-	3336	983
Cyanide (μg/L)	-	-	-	<2.3	<2.9	<2.7	-	-	<10.0	-
Hardness (mg/L)	-	-	-	-	63.0	119.0	66.0	81.0	32.0	71.0
BOD_5 (mg/L)	-	-	-	-	1.6	1.3	1.7	2.9	1.9	1.6
COD (mg/L)	-	-	-	-	17.0	11.6	6.7	-	17.5	11.6
TDS (mg/L)	205	-	-	188	169	156	-	-	-	166
NO_2+NO_3 (mg/L)	-	-	-	-	0.37	0.45	0.34	-	0.22	0.54
pH	7.8	7.6	7.5	7.6	6.5	7.7	7.4	6.7	6.9	7.7[e]

a. Numbers given are averages of the available data, 1970-1983, in each basin reach.
b. Numbers indicate the river mile reaches.
c. Rivers and streams tributary to the Clinch River upstream of Melton Hill Dam; 12 sampling locations - 1970-1981, TVA/STORET data.
d. Atypical data in the Ollis Creek watershed (a surface, strip-mined area) are not included.
e. Atypical data in the Ollis Creek watershed and Norris Reservoir are not included.

TABLE 6

COMPARISON OF MEAN VALUES FOR VARIOUS CHEMICAL PARAMETERS IN SEDIMENT[a]

Parameter	East Fork Poplar Creek[b]			Poplar Creek		Lower Clinch River	Tennessee River	Bear Creek	White Oak Creek	Clinch River and Its Tributaries[c]
	15-10	10-5	5-0	6-3	3-0	10	565-530	8-0	4-0	
Mercury	45.6	24.0	21.9	13.1	10.0	6.39	1.24	2.03	2.05	<0.16
Cadmium	<400	-	<83.2	<4.55	<4.46	<4.0	1.13	<400	0.65	1.43
Chromium	150	76.0	75.1	92.5	111	69.5	25.7	<100	6.5	19.3
Copper	135	-	64.4	81.4	73.6	29.2	7.8	50	8.9	18.2
Lead	-	-	41.5	40.7	52.5	23.1	52.7	-	20.0	31.6
Nickel	<100	-	76.9	178	139	32.4	25.2	<100	6.5	30.5
Zinc	<800	-	190	113	127	57.8	85.0	<1350	48.0	69.6
PCB	0.21	-	1.74	4.29	5.34	-	-	-	1.05	-
Aluminum	76250	-	45714	40372	48866	34917	3000	45000	-	7452
Beryllium	<10	-	<10	-	<0.60	-	<0.60	<10	<0.60	<1.0
Manganese	-	-	584	588	593	624	670	-	1255	1093

a. Numbers given are averages of the available data, 1970-1983, in each basin reach. All concentrations given in μg/g, dry weight (ppm).
b. Numbers indicate the stream mile reaches.
c. Rivers and streams tributary to the Clinch River upstream of Melton Hill Dam (CRM 23.1); 12 sampling locations - 1970-1981, TVA/STORET data.

TABLE 7

COMPARISON OF MEAN VALUES FOR VARIOUS CHEMICAL PARAMETERS IN FISH IN POPLAR CREEK[a]

Parameter[b]	Bluegill	LM Bass	Giz. Shad	Lepomis	Chan. Cat.	Approximate Range of Background Concentrations[c]	FDA Action Level
Mercury	0.31	0.59	0.04	0.43	0.39	0.05-0.20	1.0
Cadmium	0.02	0.01	0.01	0.02	0.01	0.02-0.07	-
Chromium	0.16	0.19	0.07	0.03	0.33	0.03-0.10	-
Copper	0.40	0.45	0.87	0.23	0.58	0.15-0.90	-
Lead	0.06	0.10	0.08	0.10	0.12	0.03-0.70	d
Nickel	0.78	0.56	1.28	0.66	1.42	0.20-0.60	-
Zinc	8.7	8.1	3.9	7.1	5.3	5-10	d
PCB	0.17	0.38	0.27	0.30	1.6	<0.10	5.0

a. Numbers given are averages of the available data, 1976-1983.
b. All concentrations given in μg/g (ppm).
c. Based primarily on the State-wide mean concentrations for trace metals in fish (Sinclair _et al._, 1979) and on average concentrations in Melton Hill Reservoir at CRM 52.2.
d. The U.S. Food and Drug Administration (FDA) has no recommended action level for lead or zinc, but the Canadian Food and Drug Directorate has set standards of 10 and 100 ppm, respectively, for these metals.

TABLE 8

COMPARISON OF MEAN VALUES FOR VARIOUS CHEMICAL PARAMETERS IN FISH IN THE LOWER CLINCH RIVER BELOW MELTON HILL DAM[a]

Parameter[b]	Bluegill	LM Bass	Giz. Shad	Lepomis	Approximate Range of Background Concentrations[c]	FDA Action Level
Mercury	0.30	0.23	0.05	0.37	0.05-0.20	1.0
Cadmium	0.01	0.01	0.01	0.01	0.02-0.07	-
Chromium	0.05	0.08	0.17	0.03	0.03-0.10	-
Copper	0.25	0.33	0.63	0.30	0.15-0.90	-
Lead	0.07	0.12	0.10	0.14	0.03-0.70	d
Nickel	0.72	0.55	0.51	0.60	0.20-0.60	-
Zinc	6.4	5.8	4.1	11.1	5-10	d
PCB	-	0.20	0.22	0.15	<0.10	5.0

a. Numbers given are averages of the available data, 1976-1983.
b. All concentrations given in μg/g (ppm).
c. Based primarily on the State-wide mean concentrations for trace metals in fish (Sinclair *et al.*, 1979) and on average concentrations in Melton Hill Reservoir at CRM 52.2.
d. The U.S. Food and Drug Administration (FDA) has no recommended action level for lead or zinc, but the Canadian Food and Drug Directorate has set standards of 10 and 100 ppm, respectively, for these metals.

CRITERIA AND SELECTED DATA FOR
CHEMICAL PARAMETERS IN WATER

Parameter (Units)	TN Source Standards[a]	EPA Drinking Water Standards[b,c]	Aquatic Life[d]		Mean Concentrations of Tributary Streams to Upper Tennessee River[e]
			24-hr Avg	Maximum	
Temperature (°C)	30	-	-	-	15.0
Dissolved oxygen (mg/L)	-	-	5.0[f]	-	8.8
pH (standard units)	6-9	6.5-8.5	6.5-9.0	-	6.9
Conductance, (μmhos/cm)	-	-	-	-	192
Turbidity (JTU)	-	1	-	-	9.5
Total dissolved solids (mg/L)	500	500	500	-	101
Ammonia nitrogen (mg/L as N)	-	-	-	0.02[g]	0.09
Nitrite + nitrate nitrogen (mg/L as N)	10 (as NO_3-N)	10 (as NO_3-N)	-	-	0.39
Total organic carbon (mg/L)	-	-	-	-	2.87
Total phosphorus (mg/L)	-	-	-	-	0.04
Chloride (mg/L)	250	250	-	-	3.9
Sulfate (mg/L)	250	250	-	-	20.6[j]
Fluoride (mg/L)	-	1.6	-	-	0.07
Aluminum (μg/L)	-	-	-	-	761
Arsenic (μg/L)	50	50	40	440	<3.9
Barium (μg/L)	1,000	1,000	-	-	<100
Beryllium (μg/L)	-	-	5.3	130	<10
Boron (μg/L)	-	-	-	-	246
Cadmium (μg/L)	10	10	0.025[h]	3.0[h]	<1.8
Chromium (μg/L)	50	50[i]	-	100[i]	<4.2
Cobalt (μg/L)	50	-	-	-	21.6
Copper (μg/L)	1,000	1,000	5.6	22[h]	47
Iron (μg/L)	-	300	-	1,000	853[j]
Lead (μg/L)	50	50	3.8[h]	170[h]	<16.8
Lithium (μg/L)	-	-	-	-	<10
Manganese (μg/L)	-	50	-	-	110[j]
Mercury (μg/L)	0.2	2	0.2	4.1	<0.4
Molybdenum (μg/L)	-	-	-	-	-
Nickel (μg/L)	100	-	96[h]	1,800[h]	<48
Selenium (μg/L)	10	10	35	260	<8
Silver (μg/L)	50	50	-	4.1[h]	<10
Vanadium (μg/L)	-	-	-	-	<322
Zinc (μg/L)	5,000	5,000	47	320[h]	126
Cyanide (mg/L)	200	-	3.5	52	<0.01

a. Tennessee Drinking Water Source Standards, 1983.
b. National Interim Primary Drinking Water Standards, 40 CFR Part 141.
c. National Secondary Drinking Water Standards, 40 CFR Part 143.
d. EPA Water Quality Criteria for the Protection of Aquatic Life. Criteria listed are from EPA's Quality Criteria for Water (1976) ("Red Book") and from EPA's 1980 Water Quality Criteria for Priority Pollutants (see 45 FR 79318-79341, November 28, 1980).
e. Average concentrations in water for streams tributary to the Tennessee River between miles 424 and 652; 43 sampling locations - 1960 to 1983, TVA STORET data.
f. The 5.0 mg/L criteria for dissolved oxygen is a minimum value rather a 24-hour average.
g. 0.02 as unionized ammonia. See EPA's 1976 Quality Criteria for Water, p. 16 for further explanation.
h. Values calculated for a hardness of 100 mg/L using the equations given in 45 FR 79318-341. Increasing hardness generally decreases toxicity of these metals.
i. National Interim Primary Drinking Water Standard is 50 μg/L for hexavalent chromium (Cr^{+6}). The criteria listed for aquatic life, irrigation, and livestock are for total chromium, which was the species measured in this study.
j. Atypical data from the Ollis Creek watershed (a surface, strip-mined area) were not included.

TABLE 9

TABLE 10

CRITERIA AND SELECTED DATA FOR
CHEMICAL PARAMETERS IN SEDIMENT AND SOIL

Parameter[a] (ppm)	Proposed Virginia Criteria[b]	Average Earth's Crust[c]	Mean Concentrations of Upper Tennessee River[d]	Mean Concentrations of Tributary Streams to Upper Tennessee River[e]	Mean Concentrations of Clinch River[f]
Mercury	0.3	0.5	1.0 (<0.05-4.3)	0.25 (<0.05-0.98)	<0.16[g] (<0.05-0.41)
Cadmium	-	0.2	5.5 (0.4-12.0)	1.8 (<0.4-11.0)	1.4 (<0.4-3.7)
Chromium	-	200	48.0 (14.0-86.0)	19.7 (5.0-46.0)	19.3 (6.3-44.7)
Copper	-	70	38.0 (5.9-67.0)	47.6 (3.0-320.0[h])	18.2 (3.0-48.0)
Lead	-	16	59.7 (<10.0-99.0)	47.9 (<3.0-300.0)	31.6 (13.1-72.0)
Nickel	-	100	33.6 (5.8-57.0)	22.4 (<3.3-70.0)	30.0 (16.0-70.0)
Zinc	-	80	670 (85-1,600)	165 (20-940)	69.6 (31.6-140)
PCBs	-	-	-	-	-
Aluminum	-	81,000	25,590 (3,000-46,000)	8,684 (1,200-21,000)	7,453 (2,720-13,700)
Beryllium	-	6	1.9 (<0.3-4.0)	0.93 (<0.6-1.9)	<1.0 (<0.7-1.0)
Manganese	-	1,000	2,619 (670-5,300)	1,133 (150-14,000)	1,093 (442-3,100)

a. Concentrations given in mg/kg (ppm), dry weight, range in parenthesis.
b. State of Virginia proposed regulation for total mercury in freshwater river sediment.
c. After Y. M. Goldschmidt. Courtesy A. Muir, editor, and Clarendon Press, Oxford, publishers of "Geochemistry," average abundance of trace elements in the crust of the earth.
d. Average concentrations in river sediment for reach from Nickajack Dam to confluence of the Holston and French Broad Rivers, TRMs 424 to 652; 24 sampling locations - 1970 to 1983, TVA STORET data.
e. Average concentrations in river sediment for streams tributary to the Tennessee River between miles 424 and 652; 43 sampling locations 1970 to 1981, TVA STORET data.
f. Average concentrations in Clinch River sediment above Melton Hill Dam, CRM 22; 12 sampling locations - 1970 to 1981, TVA STORET data.
g. Seven of twelve samples below detection limits.
h. Ocoee River - downstream of Copperhill, Tennessee.

TABLE 11

CRITERIA AND SELECTED DATA FOR CHEMICAL PARAMETERS IN FISH

Parameter[a] (ppm)	FDA Criteria[b]	Tennessee State-Wide Mean[c]	Melton Hill Reservoir CRM 52.2[d] Bluegill	Great Smoky Mountains National Park[e] Rainbow Trout	Skinface Pond South Carolina[f] Largemouth Bass	Skinface Pond South Carolina[f] Bluegill	Cayuga Lake New York[g] Lake Trout	Wintergreen Lake Illinois[h] Largemouth Bass	Wintergreen Lake Illinois[h] Hybrid Sunfish
Mercury	1.0	0.28	0.06 (0.03-0.08)	0.036[i] (0.003-0.177)	-	-	-	0.468 (0.189-0.899)	0.255 (0.136-0.382)
Cadmium	-	0.07	0.018 (0.001-0.042)	-	-	-	0.0041 (0.0021-0.0063)	0.036 (0.020-0.048)	0.039 (0.026-0.051)
Chromium	-	0.11	0.030 (0.022-0.044)	-	-	-	0.016 (0.002-0.090)	-	-
Copper	-	0.87	0.16 (0.06-0.30)	-	0.22 (0.09-0.50)	0.12 (0.07-0.22)	0.022 (0.015-0.036)	-	-
Lead	-	0.70	0.027 (0.017-0.042)	-	0.1[j] (<0.1-0.4)	0.3[j] (<0.1-1.1)	0.011 (0.004-0.022)	0.301 (0.170-0.445)	0.198 (0.030-0.414)
Nickel	-	-	0.40 (0.23-0.65)	-	-	-	0.014 (0.007-0.023)	-	-
Zinc	-	-	5.4 (4.5-7.5)	-	2.5 (1.4-4.9)	6.3 (2.5-9.7)	0.210 (0.035-0.048)	-	-
PCBs	5.0	-	-	-	-	-	-	-	-
Aluminum	-	-	-	-	-	-	-	-	-
Beryllium	-	-	-	-	-	-	-	-	-
Manganese	-	-	-	-	-	-	-	-	-

a. Concentrations given μg/g (ppm), wet weight, range in parentheses.
b. The Food and Drug Administration recommends a criterion of 1.0 ppm and 5.0 ppm for mercury and PCBs, respectively, in fish flesh.
c. Sinclair, et al. (1979). Heavy Metals Concentrations in Fish Tissue in Tennessee (1977-78). Tennessee Department of Public Health, Division of Water Quality Control.
d. Loar, et al. (1981). Description of the Aquatic Ecology of White Oak Creek Watershed and the Clinch River Below Melton Hill Dam. ORNL Report TM-7509/V2.
e. Huckabee, et al. (1974). "Mercury Concentrations in Fish from the Great Smoky Mountains National Park." Anal. Chim. Acta 70:41-47. No size/age data reported.
f. Wiener and Giesy. (1979). "Concentrations of Cd, Cu, Mn, Pb, and Zn in Fishes in a Highly Organic Softwater Pond." J. Fish. Res. Board Canada 36:270-279. Wet wt. of fish ranged from 51.3 to 1191.8 g and 97.7 to 351.2 g for largemouth bass and bluegill, respectively.
g. Tong, et al. (1974). "Trace Metals in Lake Cayuga Lake Trout (Salvelinus namaycush) in Relation to Age." J. Fish. Res. Board Canada 31:238-239. Composite sample of three decapitated and eviscerated fish was analyzed for each of 12 age classes.
h. Mathis and Kevern. (1975). "Distribution of Mercury, Cadmium, Lead, and Thallium in a Eutrophic Lake." Hydrobiologia 46:207-222. Largemouth bass used in Hg analysis ranged from 400 to 2400 g (no additional size/age data reported).
i. Value based on both axial and whole body determinations.
j. Whole body concentration. Wet wt. of fish ranged from 0.34 to 69.36 g and 0.03 to 20.58 g for largemouth bass and bluegill, respectively.

SUMMARY OF CONCLUSIONS REGARDING CONCENTRATIONS IN FISH, SEDIMENT, AND WATER

PARAMETER	SIGNIFICANTLY ABOVE BACKGROUND LEVELS			INADEQUATE DATA			NOT SIGNIFICANTLY ABOVE BACKGROUND CONCENTRATIONS		
	Fish[b]	Sediment	Water	Fish[b]	Sediment	Water	Fish[b]	Sediment	Water
MERCURY	●	●	●						
CADMIUM[a]					●	●	●		
CHROMIUM	●	●	●						
COPPER		●				●	●		
LEAD		●				●	●		
NICKEL	●	●				●			
ZINC							●	●	●
PCB	●				●	●			
ALUMINUM				●				●	●
BERYLLIUM[a]				●	●	●			
MANGANESE				●				●	●
TOXIC ORGANICS				●	●	●			

[a] Detection limit problems, especially with older data.

[b] Comparisons for all parameters except mercury are based on data from Poplar Creek and the lower Clinch River.

TABLE 12

COMPARISON OF AVERAGE CONCENTRATIONS FOR SELECTED PARAMETERS IN SEDIMENT

LOCATION	RIVER MILES	MERCURY	CHROMIUM	COPPER	LEAD	NICKEL
EAST FORK	10-15	45.6	150	135	—	<100
POPLAR CREEK	5-10	24.0	76	—	—	—
	0-5	21.9	75.1	64.4	41.5	76.9
POPLAR CREEK	3-6	13.1	92.5	81.4	40.7	178
	0-3	10.0	111	73.6	52.5	139
CLINCH RIVER	10	6.39	69.1	29.2	23.1	32.4
TENNESSEE RIVER	(530-565)	1.24	25.7	7.80	52.7	25.2
BEAR CREEK	(0-8)	2.03	<100	50	—	<100
WHITE OAK CREEK	(0-4)	2.05	6.5	8.9	20.0	12.5
CLINCH RIVER AND ITS TRIBUTARIES[b]		<0.16	19.3	18.2	31.6	30.5

[a] Numbers given are averages of the available data, 1970-1983, in each basin reach. All concentrations given in µg/g(ppm).

[b] Rivers and streams tributary to the Clinch River upstream of Melton Hill Dam (CRM 23.1); 12 sampling locations - 1970 to 1981, TVA/STORET data.

TABLE 13

COMPARISON OF AVERAGE CONCENTRATIONS FOR SELECTED PARAMETERS IN FISH FROM POPLAR CREEK[a]

SPECIES	MERCURY	CHROMIUM	NICKEL	PCB
BLUEGILL	0.31	0.16	0.78	0.17
LM BASS	0.59	0.19	0.56	0.38
GIZZARD SHAD	0.04	0.07	1.28	0.27
LEPOMIS	0.43	0.03	0.66	0.30
CHANNEL CATFISH	0.39	0.33	1.42	1.6
APPROXIMATE RANGE OF BACKGROUND CONCENTRATIONS[b]	(0.05-0.20)	(0.03-0.10)	(0.20-0.60)	$<$0.10

[a] Numbers given are averages of the available data, 1976-1983. All concentrations given in µg/g(ppm).

[b] Based primarily on state-wide mean concentrations for trace metals in fish (Sinclair *et al*, 1979) and on average concentrations in Melton Hill Reservoir at CRM 52.2

TABLE 14

TABLE 15

MERCURY CONCENTRATIONS IN SEDIMENTS OF THE UPPER TENNESSEE RIVER*

RESERVOIR	RIVER REACH SAMPLED	NUMBER OF SAMPLES	MEAN CONCENTRATION (µg/g)
FORT LOUDOUN/WATTS BAR	TRM 650.0-579.0	10	0.27
(CLINCH RIVER)	TRM 567.7	—	—
WATTS BAR	TRM 560.8-531.0	4	1.09
CHICKAMAUGA	TRM 508.0-472.3	15	1.75
NICKAJACK	TRM 459.0-425.5	10	0.53

*Approximate range of background concentrations in unpolluted waters of the Tennessee Valley = 0.1-0.3 µg/g

Mercury Analysis of Soils in the Oak Ridge Area

	Location	No. of Samples	Mean Conc. (µg/g)	Standard Deviation
1.	Greenview Estates	16	8.31	10.4
2.	Robertsville Jr. High	12	14.1	12.10
3.	YWCA	7	0.23	0.05
Robertsville, Jr. High Area				
4.	Valparaiso Road	1	10.4	-
5.	Victoria Road	3	0.048	0.025
6.	Hollywood Road	1	0.046	-
East Fork Poplar Creek Area				
7.	Big Turtle Park/Wiltshire Boulevard	12	0.243	0.234
	Wiltshire Sewer Beltway	5	32.8	20.8
8.	Gum Hollow Road/Greystone Lane	4	0.571	0.331
9.	Between Greenview Estates and Jefferson Avenue - Including Floodplain	17	11.8	30.1
10.	Background			
	a. Freels Bend	3	0.117	0.076
	b. Union Road	5	0.08	0.027
	c. Lamberts Quarry - Noncontaminated	4	0.063	0.025
	d. Raccoon Creek	1	0.004	-
11.	Jefferson Jr. High	6	11.4	15.5
12.	Jefferson Jr. High Area - Includes Sewer Belt	22	125	93.2
13.	Warehouse Road Bellgrade Road Colgate Road	11	15.1	44.9
14.	Scarboro Area	33	3.37	16.8
15.	ORNL	19	1.66	3.01

TABLE 16

APPENDIX III - List of June 14, 1983 Data Received

Reed 6/14/83

Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

June 14, 1983

Tennessee Valley Authority
ATTN: Mr. Jack Milligan
Water Quality Control Branch
401 Building
Chattanooga, Tennessee 37401

Gentlemen:

REQUEST FOR INFORMATION

Reference is made to Mr. A. D. McKinney's letter dated May 16, 1983, subject as above, copy to you. As requested in his letter, enclosed is the data related to mercury in the environment.

There were three items on the TN/DPH list that I was unable to identify (marked by red "stars"). I am requesting copies of these from Mr. McKinney. If they are different from the information attached, I will forward these to you as soon as possible.

If you have any questions or need any additional information, you can contact me at (615) 576-0845.

Sincerely,

J. F. Wing

J. F. Wing, Chief
Environmental Protection Branch
Safety and Environmental Control Division

SE-331:BLQ

Enclosures:
As stated

cc w/o encl:
A. D. McKinney, TN/DPH

Rec'd 6/2/83.

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
EAST TENNESSEE REGIONAL OFFICE
ALEX B. SHIPLEY REGIONAL HEALTH CENTER
1522 CHEROKEE TRAIL
KNOXVILLE, TENNESSEE 37920

May 16, 1983

Mr. J. F. Wing, Chief
Environmental Protection Branch
Department of Energy
P.O. Box E
Oak Ridge, TN 37830

Re: Request for Information

Dear Mr. Wing:

At a meeting in our office last October, you presented us with data concerning environmental monitoring in the Oak Ridge area. Included was a report with a cover letter dated October 26, 1982, containing the heading "Submission of DOE Acquired Data Relating to Metals and Organics Levels in Local Fishery and Sediments." This report included four pages listing documents used as references.

We have compared those lists with documents submitted and find we do not have all that are needed to fully assess the situation in question. Some documents were submitted only in part and others apparently omitted. It is possible that titles in the listing do not exactly match those of documents on hand, and thus, we may think them to have been omitted.

Enclosed you will find copies of lists from your report. Please submit to this office complete copies of those documents marked by an asterisk. Also enclosed is a catalogue of all documents we do have in their complete form. We request that a copy of each of these along with a copy of each of the documents marked on the first lists be sent to the following address:

Jack Millgan, Tennessee Valley Authority
Water Quality Control Branch
401 Building
Chattanooga, TN 37401

Mr. J. F. Wing, Chief
Page 2
May 16, 1983

Please call if you have any questions regarding this request for information.

Sincerely,

Aubrey D. McKinney, Manager
Knoxville Basin Office
Division of Water Management

ADM/BWS/kav A/17

cc: Jack Milligan, TVA

Preliminary Study, Mercury Contamination In East Fork Poplar Creek and Bear Creek, 1982

* Mercury in Fish 1978 - Fish From: Melton Hill, East Fork Poplar Creek, Clinch River, Rogers Quarry, and New Hope Pond Need

* Fish Analysis 1977 - Mercury Heavy Metals

Mercury in Fish 1977 - Poplar Creek, Clinch River

Mercury in Fish 1977 - Popular Creek

* East Fork Poplar Creek 1970-1976

* Mercury Content of Fish Samples 1976, Poplar Creek, Melton Hill Lake

Mercury in Fish 1976, Melton Hill Lake, Clinch River, Poplar Creek

Mercury in Fish, Poplar Creek 1976

Mercury Fish, Clinch River 1976

Preliminary Aquatic Survey East Fork Poplar Creek and Bear Creek, 1975

Preliminary Aquatic Survey of East Fork Poplar Creek and Bear Creek 1974

Preliminary Aquatic Survey of East Fork Poplar Creek and Bear Creek 1973

Aquatic Survey East Fork Poplar Creek and Bear Creek 1973

Preliminary Aquatic Survey of East Fork Poplar Creek and Bear Creek, 1972

* - Need Copy

ORNL Drawing 81-9373

ORNL Drawing 81-9374

Clinch River Sediment Data - Appendix A

ORNL/TM-6714-1981 - Ecological Studies of the Biotic Communities in the Vicinity of the Oak Ridge Gaseous Diffusion Plant

Y/UB-16 - Environmental Monitoring Report, U.S.DOE, Oak Ridge Facilities, Calendar Year 1981

Y/UB-15 - Environmental Monitoring Report, U.S.DOE, Oak Ridge Facilities, Calendar Year 1980

ORNL/TM-7509/V2-~~1979~~ 1981 - Technical Background Information for the ORNL Environmental and Safety Report, Volume 2

Y/UB-13 - Environmental Monitoring Report, U.S.DOE, Oak Ridge Facilities, Calendar Year 1979

ORNL/TM-6895-1978 - Association of Radionuclides with Streambed Sediments in White Oak Creek Watershed

Y/UB-10 - Environmental Monitoring Report, U.S.DOE, Oak Ridge Facilities, Calendar Year 1978

Y/UB-8 - Environmental Monitoring Report, U.S.DOE, Oak Ridge Facilities, Calendar Year 1977

Y/UB-6 - Environmental Monitoring Report, U.S.ERDA, Oak Ridge Facilities, Calendar Year 1976

ORNL-5169 - Applied Health Physics and Safety Annual Report for 1975

Y/UB-4 - Environmental Monitoring Report, U.S.ERDA, Oak Ridge Facilities, Calendar Year 1975

ORNL-5055 - Applied Health Physics and Safety, Annual Report for 1974

UCC-ND-302 - Environmental Monitoring Report, U.S.ERDA, Oak Ridge Facilities, Calendar Year 1974

ORNL-4974 - Applied Health Physics and Safety, Annual Report for 1973

UCC-ND-280 - Environmental Monitoring Report, U.S.AEC, Oak Ridge Facilities, Calendar Year 1973

ORNL-4894 - Applied Health Physics and Safety, Annual Report for 1972

ORNL-4848 - Environmental Sciences Division, Annual Progress Report, Period Ending September 30, 1972

*ORNL-4795 - Applied Health Physics and Safety, Annual Report 1971

*ORNL-4445-UC-48-Biology and Medicine

*ORNL-4423-UC-41-Health and Safety, Applied Health Physics and Safety Annual Report for 1968

*ORNL-4316, UC-41-Health and Safety, Health Physics Division, Annual Progress Report for Period Ending July 31, 1968

*ORNL-4286-UC-41-Health and Safety, Health Physics and Safety, Annual Report for 1967

ORNL-4035-UC-70-Waste Disposal and Processing-1967, Clinch River Study

ORNL-3721, Supplemental 2B, UC-70-Waste Disposal and Processing, 1967, Radioactive Materials in Bottom Sediment of Clinch River: Part B, Inventory and Vertical distribution of Radionuclides in Undisturbed Cores

ORNL-3721, Supplement 2A, UC-70-Waste Disposal and Processing, Radioactive Materials in Bottom Sediment of Clinch River: Part A, Investigations of Radionuclides in Upper Portion of Sediment

*ORNL-4007-UC-41-Health and Safety, Health Physics Division Annual Progress Report for Period Ending July 31, 1966

*ORNL-4146-UC-41-Health and Safety, Health Physics and Safety Annual Report for 1966

*ORNL-3969-UC-41-Health and Safety, Health Physics and Safety Annual Report for 1965

*ORNL-3849-UC-41-Health and Safety TID-4500 (44th ed.), Health Physics Division Annual Progress Report for Period Ending July 31, 1965

ORNL-3721, UC-70-Waste Disposal and Processing, TID-4500 (44th ed.), 1965, Status Report No. 5 on Clinch River Study

*ORNL-3820-UC-41-Health and Safety, TID-4500 (41st ed.), Applied Health Physics Annual Report for 1964

*ORNL-3697, UC-41-Health and Safety, TID-4500 (34th ed.), Health Physics Division Annual Progress Report for Period Ending July 31, 1964

*ORNL-3665-UC-41-Health and Safety, TID-4500 (31st ed.), Applied Health Physics Annual Report for 1963

*ORNL-3492-UC-41-Health and Safety, TID-4500 (22nd ed.), Health Phsycis Division Annual Progress Report for Period Ending June 30, 1963

ORNL-3409,UC-70-Waste Disposal and Processing, TID-4500 (21st ed.), 1963, Status Report No. 4 on Clinch River Study

D.O.E. Publications
Re: Fish and Sediments Clinch River and Poplar Creek Systems

1970

Date: August 6, 1970
Title: Mercury Analysis - Cover Corresp. M. Sanders to J.D. McLendon
Source: Union Carbide - Radiation Safety Dept. (Y-12?) - 2373 - Carbide
I.D. #: 2373?
Contents: Mercury Analysis in fish, water and mud
New Hope, EFPC, Bear Cr., Melton Hill

1972

Date: September 1972
Title: Preliminary Aquatic Survey of EFPC & BC - 1972
Source: AEC - Gail McClain - summer student project
I.D. #: None
Contents: Fauna, pH, D.O., Silt. Deposits - general observations

1973

Date: Spring 1973
Title: Aquatic Survey EFPC & BC
Source: Scott Wing & Fred Needham (students)
I.D.#: None
Contents: DO, pH, nutrients, Cl_2, - general observation EFPC & BC

Date: September 1973
Title: Preliminary Aquatic Survey of EFPC & BC
Source: John Reece - AEC Environmental Protection Branch
I.D. #: None
Contents: Chemical & Physical Data on EFPC & BC - Sediments

1974

Date: September 1974
Title: Preliminary Aquatic Survey EFPC & BC
Source: AEC - Envir. Prot. Branch - John Reece
I.D. #: None
Contents: Sediment and Water Data incl. Pu, U, Th, Hg & Rad levels
EFPC, BC, Clinch, Oak Ridge General

Date: November 1974
Title: Bottom Sediment Data for Stream & Ponds on OR DOE Reservations
Source: AEC - Cover Corresp. RG Jordon, AEC Safety & Envir. Branch to AEC's
W'm Travis
I.D.#: None
Contents: PCB Sediment Data New Hope, Y-12 Sludge Pond, EFPC, PC, K-25,
Clinch River, White Oak

1975

Date: 1975
Title: Environmental Monitoring Report
Source: ERDA - OR - Carbide
I.D. #: Y/UB-4
Contents: Annual Report w/Fish Rad Data (Avg.) Clinch R. and Melton Hill & P.C.
Metals in Sediment Data

Date: 1975
Title: Applied Health Physics & Safety Annual Report
Source: ORNL
I.D.#: ORNL-5169
Contents: Aug. Rad Fish Data in Clinch River - refers to Table 4.41, page 52
U & Pu in soils - (not included)

Date: September 1975
Title: Preliminary Aquatic Survey of EFPC & BC
Source: ERDA Env. Protection Branch - John Reece - ORO
I.D.#: None
Contents: DO, NH_3, NO_2, General Physical Data EFPC & BC

1976

Date: Summer, Fall 1976
Title: Mercury in Fish
Source: Unknown (Abee?)
I.D.#: None
Contents: Hg levels in fish from Clinch, Poplar Creek, Melton Hill

Date: Calendar Year 1976
Title: Envir. Monitoring Report
Source: Carbide
I.D.#: Y/UB-6
Contents: Rad in Fish in Clinch & Melton Hill
Avg. Stream Sediment Data for Heavy Metals P.C. & Clinch

Date: October 1, 1976
Title: Fish Analysis
Source: Unknown
I.D.#: None
Contents: U, Th, PCB, Hg data for fish from Kerr Hollow, Loudon Lake, Rogers Quarry, Poplar Creek

Date: 1976
Title: Clinch River & Poplar Creek Fish Sampling Data
Source: ORNL - Cover Corres. J. Elwood to Michael Ellis, K-25
I.D.#: None
Contents: Summary Report of 1976 Hg. in Fish Studies

1977

Date: June 6, 1977
Title: Mercury Contamination in Poplar Creek and Clinch River
Source: ORNL
I.D.#: ORNL/CF-77/320
Contents: Fish & Sediment Data/EFPC, PC, Bear Creek, Clinch River

Date: June 21, 1977
Title: Environmental Monitoring Report
Source: DOE
I.D.#: Y/UB-8
Contents: Calendar Year Environmental Monitoring Air, Water, Sediments, Biological, Dose Calculations - Metals & RAD

Date: July 8, 1977
Title: Draft - Mercury Contamination of Poplar Creek and Clinch River
Source: ORNL - Cover corresponsence Brooks to Hart
I.D.#: TVA Correspondence 3822
Contents: Mercury data - sediments

Date: May 6, 1977
Title: Mercury in Fish in Poplar Creek
Source: ORNL
I.D.#: Cover Correspondence Wing to Travis
Contents: 1976 Fishery Data - Mercury

Date: September 30, 1977
Title: Clinch River & Poplar Creek Fish Sampling Data
Source: ORNL/DOE
I.D.#: Correspondence to Loar
Contents: Fishery Data - Heavy Metals & PCB

1978

Date: July 31, 1978
Title: Summary Correspondence
DOE - ORO/TVA - DEP Concerning Mercury in Poplar Creek
Source: DOE
I.D.#:
Contents: Fishery Data & Heavy Metals & PCB

Date: October 4, 1978
Title: Fishery Data - Melton Hill, Clinch River, Poplar Creek, Rogers Quarry, New Hope Pond
Source: DOE
I.D.#:
Contents: Fishery - Mercury - Data

Date: Calendar year 1978
Title: Environmental Monitoring Report
Source: DOE
Contents: Air, Water, Sediments, Biological, Dose Calculations - Metals & RAD
I.D.#: Y/UB-10

Date: August 18, 1978
Title: Clinch River Fishery Data (Mercury)
Source: TWQC
I.D.#:
Contents: Mercury in Fish Flesh & Organs Clinch River

1979

Date: December of 1979
Title: Environmental Assessment of Oak Ridge Gaseous Diffusion Plant
Source: DOE
I.D.#: DOE/EA-0106
Contents: Water Quality & Sediment Data Metals & PCB

Date: Calendar Year 1979
Title: Environmental Monitoring Report DOE Oak Ridge Facilities
Source: DOE
I.D.#: Y/UB-13
Contents: Air - Water - Biological Monitoring Heavy Metals, Radiological

Date: April 10, 1979
Title: Clinch River & Poplar Creek
Bottom Sediments Data - Special Sampling
Source: DOE
I.D.#: K-1551, MS 127
Contents: PCB, in sediments

1980

Date: Calendar year 1980
Title: Environmental Monitoring Report
DOE Oak Ridge Facilities
Source: DOE
I.D.#: Y/UB-15
Contents: Annual Monitoring Report

1981

Date: Calendar Year 1981
Title: Environmental Monitoring Report DOE Oak Ridge Facilities
Source: DOE
I.D.#: Y-UB-16
Contents: Annual Report

Date: October 1981
Title: Ecological Studies of Biotic Communities in Vicinity of the O.R. Gaseous Diffusion Plant
Source: DOE
I.D.#: ORNL/TM-6714
Contents: Fishery and Sediment Data
Metals - Organics - (PCB) Radiological

Date: October 1981
Technical background information for the ORNL Envi. and Safety Report - Volume 2
Source: ORNL
I.D.#: ORNL/TM-7509/V2
Contents: Aquatic Ecology of White Oak Watershed and Clinch River Biological Communities and Metals in Fish

1982

Date: September 7, 1982
Title: Mercury Contamination in EFPC and Bear Creek
Source: ORNL
I.D.#: ORNL/CF-82/257
Contents: Sediment/Fishery/Agriculture
Mercury Data EFPC

Date: October 8, 1982
Title: Poplar Creek Fish Sampling
Special Sampling
Source: DOE
I.D.#: K-1551, MS127
Contents: Methyl Mercury - Uranium - and 1260 (PCB) in Fish Flesh

Date: October 14, 1982
Title: Sample Site description - Poplar Creek Biological (fishery) sample
Source: DOE
I.D.#: Mitchel to VanWinkle
Contents: Sample sites only - no data
Trot lines for catfish

1983

Date: October 26, 1982
Title: Review of Mercury in Fish Data from East Fork Poplar Creek
Source: DOE
I.D.#: Correspondence Wing to McKinney
Contents: See Title

Date: March 8, 1983
Title: Y-12 - CSI - Notice of Noncompliance
Source: TWQC
I.D.#:
Contents: Statement of Environmental Problems

Date: April 22, 1983
Title: Memorandum of Understanding
EPA - DOE - TWQC
Source: EPA
I.D.#: 4PM - EA/AGL
Contents: MOV - See Correspondence

FISHERY STATUS ASSESSMENT OF FORT LOUDOUN RESERVOIR WITH MANAGEMENT RECOMMENDATIONS

November 1985

Division of Air & Water Resources
Office of Natural Resources
and Economic Development
Tennessee Valley Authority

TENNESSEE VALLEY AUTHORITY

Office of Natural Resources and Economic Development
Division of Air and Water Resources
Knoxville, Tennessee
and
Division of Services and Field Operations
Norris, Tennessee

FISHERY STATUS ASSESSMENT OF FORT LOUDOUN RESERVOIR WITH MANAGEMENT RECOMMENDATIONS

November 1985

TENNESSEE VALLEY AUTHORITY

Office of Natural Resources and Economic Development

Division of Air and Water Resources
Knoxville, Tennessee
and
Division of Services and Field Operations
Norris, Tennessee

FISHERY STATUS ASSESSMENT OF FORT LOUDOUN RESERVOIR WITH MANAGEMENT RECOMMENDATIONS

Prepared by

C. Michael Alexander
Allen M. Brown
Gary D. Hickman

November 1985

TVA/ONRED/AWR 86/50

EXECUTIVE SUMMARY

Since Fort Loudoun Reservoir was impounded in 1944 its waters have been subjected to many forms of both organic and chemical pollutions. High sewage loads from several malfunctioning disposal plants, unacceptable concentrations of polychlorinated biphenyls (PCBs), and many other industrial and urban pollutants have found their way into the 5,910 hectare (14,600 acre) reservoir. Current investigations examined the current status of the aquatic community in relation to these other problems. The following are key points that resulted from this investigation:

Major Findings

1. Fort Loudoun is located in a densely populated area and receives high fishing pressure.
2. High incidence of lesions and infections on adult fish in the upper end of the reservoir, probably the result of high organic loading from non-point sources.
3. Lower than expected growth of catfish, particularly in the Little River embayment area.
4. Low abundance of white crappie spawned certain years and poor condition of this species in the reservoir.
5. Large numbers of largemouth bass spawned in 1979 should produce good short-term fishing; the low abundance of younger bass is a long-term concern.
6. Marked declines in white bass and sauger populations and increases in abundance of yellow perch and yellow bass.

Management Recommendations

1. Move to restore the sauger and white bass fisheries. This process has begun with cooperative plans between TVA and TWRA to stock sauger in the reservoir and to examine causes for the decline of this species in the tailwater.
2. Control conditions (probably organic pollution) responsible for high incidence of disease in fish in upper part of the reservoir.
3. Protect the public from high concentrations of PCBs in fish flesh through appropriate warnings and regulations restricting harvest.

Additional Data Needs

1. Information on the cause(s) for the decline of sauger and white bass fisheries in the reservoir to guide restoration and maintenance efforts in the future.
2. Timely information on the degree of contamination of fish with PCBs so that the proper protective measures can be taken.
3. Further investigation of causes for poor conditions in channel catfish and white crappie in the reservoir to guide further actions.
4. Monitor survival of bass in the reservoir to determine the need for further corrective action.

INTRODUCTION

With the creation of the Tennessee Valley Authority (TVA) in 1933, the Congressional mandate included provisions for agency functions that were compatible with flood control and power generation. These provisions solidified the agency's role as a resource development agency, maintaining stewardship and insuring effective management and protection of the Valley's natural resources. These stewardship responsibilities complement the objectives of the State game and fish agencies in the seven-State region. Through close coordination and consultation between TVA and these agencies, these objectives can be achieved and natural resources maximized for their users. Freshwater sport fishing in the Tennessee Valley provides important economic benefits. Protection and improvement of sport fisheries require development of fishery management plans for individual reservoirs. Accurate, up-to-date assessment of the status of fish populations is an essential component for an informed planning process.

In the 1940s, fishing regulations were liberalized nationwide in large part because research on TVA reservoirs indicated generally low harvest rates (Eschmeyer 1945). Additional research conducted by various States led to year-round open seasons, relaxation of creel limits, and abandonment of length limits (Redmond 1972). The consensus of most biologists during this period was that overfishing a large impoundment was impossible and that fishing mortality had little effect on fish population structure. However, recent increased interest in sport fishing and sophistication of fishing equipment and technology have increased fish harvest rates on many reservoirs. Redmond (1972) reported that fishing pressure has increased nationwide from 25 trips per acre in the 1940s to 100-150 trips per acre by 1972. In Tennessee Valley reservoirs fishing pressure is considerably lower than the national average. However, recent increases in fishing for black bass in conjunction with demand for quality fishing have placed additional demands for improved management on TVA reservoirs. This significant increase in nationwide fishing pressure caused biologists to consider once again the possibility of over-exploitation of sport fishes and to realize the need for improved methods to evaluate the status of fish populations.

Fish managers have recently developed methods to evaluate the quality of a sport fishery for all species in any reservoir. This quality measurement is broken down into four categories: (1) fish that are of quality size, (2) fish that are of a preferred size by the anglers, (3) ones that are of a memorable size, and (4) those in the trophy size category (Gabelhouse 1984). The designated sizes for each of the four categories are generally determined by percentages of world record length individuals. After relatively small numbers of fish are collected from a reservoir, the quality of the sport fishery can be determined and potential problems identified. If problems are evident, additional sampling may be necessary in order to make specific management recommendations.

The objectives of the Fort Loudoun Reservoir fisheries evaluation are to: (1) analyze historical data and compare it to recent data to identify major changes and/or trends in fish populations, (2) determine the quality of the fishery for important sport fishes (black bass, white bass, sauger, and crappie), and (3) formulate management recommendations for improving populations of these species that can be used by cooperating agencies in the future.

STUDY AREA

Fort Loudoun, a mainstream reservoir covering 5,910 ha (14,600 acres) at normal summer pool (813 feet above mean sea level), was created in 1944 by completion of Fort Loudoun Dam at Tennessee River Mile (TRM) 602.3, 49.9 miles downstream from the confluence of the French Broad and Holston Rivers. It has a mean depth of 7.5 m (25 feet), an average discharge of 400 m^3/sec. (14,000 cfs) and a winter-summer fluctuation of 1.8 m (6 feet). Average water retention time in the reservoir is approximately 20 days. Fort Loudoun is a eutrophic reservoir identified as having water quality problems stemming from both urban runoff and point source discharges (TVA 1985).

Fish samples were collected from three sections of Fort Loudoun Reservoir to document intra-reservoir variations in fish stocks (figure 1). The lower area extended from Fort Loudoun Dam (TRM 602.3) to approximately TRM 615. The middle area included the Concord vicinity from TRM 615 to TRM 631. The rest of the reservoir from the latter point upstream to the confluence of Holston/French Broad Rivers (TRM 652.2) was termed the upper area.

METHODS

Fort Loudoun fish were sampled with gill nets in March 1984 to obtain representative specimens of sauger and white bass during early spring spawning migrations in the two major tributary rivers. Six sinking monofilament experimental gill nets, 30.4 m x 2.4 m, with five 6.1 m panels (12.7, 25.4, 38.1, 50.8, and 63.5 mm bar mesh size) were set for varying lengths of time on upper Fort Loudoun. Netting was scheduled during periods when there was no discharge from Douglas and Cherokee Dams.

Nets were set perpendicular to the shoreline in headwater areas. Electrofishing at night using a boat mounted unit with DC current supplemented gill net samples.

Fort Loudoun was sampled biweekly (three sample trips) during spring 1984 to collect representative length frequency data on smallmouth and largemouth bass. Electrofishing was used one night per sample week on each section sampled.

Each section was sampled during summer 1984 with experimental gill nets (six nets per area for one night period) for collection of a representative sample of channel catfish. The reservoir was also sampled in summer 1985 with 3.8 cm mesh size gill nets as part of another project, and, since size-biased sample gear was used, only age and growth and relative weight data were analyzed.

During fall 1984, black and white crappie were collected in trap nets consisting of two 1.1 m by 1.8 m aluminum frames with center braces and four 0.7 m diameter hoops. Net material was 1.3 cm treated nylon mesh and each net had a lead, 26.2 m long and 1.1 m deep, and two wings (10.7 m x 1.1 m). One net was set in each area for eight overnight periods. Additional crappie were obtained by electrofishing during fall 1984 to supplement age and growth data.

All crappie, black bass, white bass, channel catfish, and sauger collected were weighed (g) and total length measured (mm). A scale or dorsal spine (catfish) sample was taken from at least 100 individuals of each target species when possible. Scales were pressed on cellulose acetate slides and projected using a 17x modified scale projector onto a digitizing pad linked to a computer (PC) as described by Frie (1982). Spines were sectioned adjacent to the umbo region using an isomet saw and read using a binocular microscope (25x) equipped with an ocular micrometer. These measurements were then entered into the computer using the digitizing pad and a clear acetate millimeter ruler. Computer analysis of the scale and spine readings was performed by a program developed by Frie (1982) with modifications by TVA Computer Systems Development Branch Staff following the traditional Lee method to calculate the growth history lengths (Carlander 1981).

Analysis of electrofishing, experimental gill and trap netting results included calculations of proportional stock densities (PSD), relative stock densities (RSD) and relative weights (W_r). As described by Anderson (1978), proportional stock density is a percentage of the stock that is of quality size and is calculated by:

$$\text{PSD percent} = \frac{\text{number} \geqq \text{quality size x 100,}}{\text{number} \geqq \text{stock size}}$$

where; quality size = 37 percent of maximum length (table 1) and
stock size = 25 percent of maximum length.

Relative stock density (RSD) measures the "quality" of a fish population by allowing the investigator to determine the percentage of a defined size group in the stock. For example, if 380 mm and larger bass are considered important or "preferred" to a particular fishery the RSD would be calculated by:

$$\text{RSD percent} = \frac{\text{number of fish} \geqq \text{380 mm x 100}}{\text{number} \geqq \text{stock size}}$$

Memorable and trophy designations are based on 62 and 76 percent of maximum length. These categories allow further description of the quality of the fishery for that species (table 1).

Relative weight (W_r), is a measure of the relative condition of fish expressed as a percentage of a standard weight. This index is calculated by:

$$W_r = \frac{W}{W_s} \text{ x } 100,$$

where; W = actual weight and
W_s = standard weights per unit length

For this investigation, standard weights were obtained by using a length-weight relationship for a particular species based on available historical data for that species from Tennessee River mainstream reservoirs. Anderson (1980) used length-weight data obtained from Carlander (1977), which included data from throughout the range of the species, to obtain standard weight values. A W_r of 100 (± 5) is considered good. As an additional measurement of the relative well-being of the target species, growth rates (mean length at a given age) on the study reservoirs will be compared to historical (standard) growth rates in Tennessee River mainstream impoundments when these data are available.

Rotenone samples were collected from two coves (figure 1) on Fort Loudoun reservoir in August 1984 to obtain information on biomass and reproductive success. Cove selection was based on size (preferred three acres), depth, and location (one from the lower portion of the reservoir and the other from the upstream portion of the reservoir). Methods were as described in the cove rotenone section of the Field Operations Standard Procedures Manual (TVA 1983). Cove rotenone data analysis included information on species occurrence and composition of community standing stock (adult, juvenile, and young-of-year classes).

A joint TVA-Tennessee Wildlife Resources Agency creel survey on Fort Loudoun Reservoir was conducted from July 1980 through June 1984. Data were analyzed for yearly mean harvest rate (number of fish per hour), estimated number of hours expended for species intended (fisherman seeking a particular species), and harvest rates of these species-intended fishermen.

Data from two previous studies were used for PSD-RSD analysis and compared with results of this investigation. TWRA collected bass for exploitation rate studies on Fort Loudoun Reservoir during spring 1981 and 1982 (Peterson, unpublished data). An unrelated survey by TVA collected largemouth bass from the Turkey and Sinking Creek embayments during spring 1977 and 1978 (Hickman, unpublished data).

RESULTS AND DISCUSSION

Cove rotenone data provided a general description of the Fort Loudoun Reservoir fish community. Thirty-four species were collected from two coves in August 1984 (table 2). Threadfin shad were the most abundant species (51.6 percent) with gizzard shad (28.4 percent), bluegill (8.6 percent), bullhead minnow (2.4 percent), freshwater drum (2.0 percent), yellow bass (1.4 percent), and warmouth (1.0 percent) following in order of abundance (table 3). Each remaining species comprised less than 1 percent of the samples.

Rough fish, mainly carp (17.27 percent), freshwater drum (8.5 percent), smallmouth buffalo (6.4 percent), channel catfish (5.8 percent), and black buffalo (2.4 percent) comprised 40.4 percent of the total biomass (kg/ha). Forage species contributed another 40.4 percent of the total biomass with gizzard shad (30.8 percent) and threadfin shad (9.0 percent) comprising the majority of the weight. Game fish contributed 19.3 percent by weight with bluegill (10.3 percent), white crappie (2.9 percent), and largemouth bass (1.9 percent) contributing most significantly. Remaining species contributed less than one percent.

Although cove rotenone biomass estimates are typically variable from year to year, the 1984 estimate (341 kg/ha) was near the average (314 kg/ha) for historical rotenone samples from Fort Loudoun and that of mainstream reservoirs of the Tennessee River (347 kg/ha). Species composition was relatively consistent with historical data (table 4). Yellow bass and yellow perch are two species that have spread recently into Fort Loudoun with the first occurrence in rotenone samples observed in 1984. Freshwater drum showed the largest increase (264 percent) and white bass the largest decline (62 percent) in 1984, over the mean of previous samples. The white bass decline may be attributable to competition with an expanding yellow bass population. Sauger was the only other previously numerous species that was considerably less abundant in 1984. The absence of YOY sauger when compared to samples taken in the late 1950's and early 1960's is definitely cause for concern.

Twenty-two species (868 fish) were collected with experimental gill nets during summer (table 5). Gizzard shad were most abundant in the main body (from Tennessee River Mile 602.3 to 652.1) of the reservoir with a catch rate of 19.7/net night followed by carp (3.7), threadfin shad (3.1), channel catfish (2.4), skipjack herring (2.2), yellow bass (2.1), freshwater drum (1.6), blue catfish (1.2), and smallmouth buffalo (1.2). Remaining species had a catch rate less than 1.0/net night. Early spring (March-April) experimental gill net samples in the French Broad and Holston Rivers resulted in skipjack herring having the highest capture rate (1.0/net night), followed by white bass (0.3), yellow bass (0.2), channel catfish (0.2), gizzard shad (0.2), and sauger (0.1). The French Broad River had higher catch rates than the Holston River for all species, especially sauger (none collected in the Holston River).

Largemouth Bass

Spring 1984 length frequency data (figure 2) from the three sections of Fort Loudoun Reservoir indicate a recruitment problem for largemouth bass. Of 258 largemouth bass captured by electrofishing, 70 were from the upper, 104 from middle, and 84 from the lower reservoir sections (figure 2). Yearling bass were virtually absent from all areas and few two year old bass were captured. Low numbers of yearling bass in spring electrofishing samples have been attributed to sampling bias (Hevel and Hickman 1985).

A PSD index of 66 percent was calculated for largemouth bass. This value falls in the upper portion of the range (40 to 70 percent) suggested by Anderson (1980) indicating good numbers of quality bass and/or limited numbers of stock size bass. PSD's based on TWRA exploitation rate studies conducted in 1981 and 1982 were 40 and 38 percent, respectively (table 6). Results of TVA spring electrofishing in 1977 and 1978 in the Turkey and Sinking Creek areas of Fort Loudoun (mid-lake area) indicated PSD's of 36 and 72 percent, respectively. Carline et al. (1984) reported that annual variations in recruitment drives PSD indices, causing extreme oscillations in year to year PSD values. This also was apparent in this study when comparing length frequency data for 1977 and 1978. The low PSD of 1977 (36 percent) was due to an abundance of two year old fish. The following year, these fish grew to quality size which coupled with low recruitment into the stock size, caused the PSD to escalate to 72 percent. Similarly, the low PSD's seen in 1981 and 1982 (40 and 38 percent respectively) were followed by a high PSD in 1984 (66 percent) as these year-classes entered quality size.

RSD values allow for a more comprehensive look at the Fort Loudoun largemouth population. In 1984, the RSD for the preferred size group

(≧ 380 mm) was 36 percent (table 6), above the satisfactory range of 10 to 25 percent as defined by Anderson (1980). Memorable size largemouth (≧ 460 mm) in Fort Loudoun comprised 7 percent of the population and trophy fish (≧ 570 mm) made up 0.4 percent.

TVA and TWRA spring largemouth bass collection results revealed consistently lower RSD values, especially for the preferred size group, for the years 1977, 1978, 1981 and 1982 (table 6). It is probable that the large year classes in 1981 and 1982 had grown to preferred sizes by 1984. This, in conjunction with low recruitment to stock size in 1983 and 1984, resulted in the higher PSD and RSD's in 1984.

The average relative weight (W_r) of largemouth bass in Fort Loudoun was calculated to be 107, indicating they are in better condition than the average mainstream estimates. Growth data indicates below average values up to age four and above average values in age four + individuals. (figure 3.)

Fort Loudoun, especially the upper section, has a significant water quality problem, mainly involving bacterial and polychlorinated biphenyls (PCBs) contamination (TVA 1985). Field observations indicated a large percentage of the largemouth bass captured in the upper area of the reservoir had lesions or sores while very few fish in the middle and lower sections were infected. Although these data were not quantified, the differences between areas were obvious.

Smallmouth Bass

Spring electrofishing samples from the three sections of Fort Loudoun Reservoir revealed a skewed distribution of smallmouth bass with 84 from the lower portion, 66 from the middle section, and none captured from the upper area (figure 4). Yearling smallmouth bass were collected in limited numbers but two-year-olds were quite abundant indicating a strong 1983 year class.

Fort Loudoun smallmouth displayed a PSD index of 47 percent. This value indicates a balanced, or good, smallmouth population even though it is restricted to the middle and lower sections of the reservoir. RSD for the preferred size group (≧ 350 mm) was 35 percent which lies above the satisfactory range of 10 to 25 percent. Memorable size smallmouth (≧ 430 mm) in Fort Loudoun comprised 19 percent of the population while trophy smallmouth (≧ 510 mm) made up 0.8 percent in 1984. A W_r of 105 indicates smallmouth in Fort Loudoun are in better condition than the average from other Tennessee River mainstream impoundments, although they grow at a slower rate in age classes (figure 5).

White Crappie

A total of 245 white crappie was captured by spring and fall electrofishing, summer gill netting, and fall trap netting. Electrofishing was size biased for adult crappie and trap netting for juveniles with neither gear effectively collecting all sizes (figure 6). These biases have been observed by Hickman and Hevel, 1985 in other reservoirs. Gill netting captured only nine white crappie. Of all white crappie captured, 114 were from the upper lake, 72 from mid-lake, and 49 from the lower section of the reservoir (figure 7). Additionally, 10 were collected from the tributary rivers. Fall trap netting was most successful in the upper section of Fort Loudoun (4.8 per net night) followed by the lower area (0.8) and the mid-section (0.6). Spring electrofishing also captured more white crappie, though mostly adults, in the upper more eutrophic (TVA 1985) zone of the reservoir. Overall sampling results did reveal progressively increasing crappie densities from the dam to upper Fort Loudoun Reservoir (figure 7). This skewed distribution of white crappie populations has been reported (Colvin, 1985 and Hevel and Hickman, 1985).

The basic assumption relative to PSD and RSD indices of a sample accurately representing the size structure of the reservoir population was not met, therefore these parameters could not be reliably calculated for white crappie. Growth (figure 8) and condition (W_r 95) was below normal.

Sauger

Only thirty sauger were collected during this investigation which was (figure 9) not enough for PSD and RSD calculations. Twenty-six were collected in headwater areas, two in the lower and two in the middle areas of the reservoir. These latter four sauger ranged 172 mm to 264 mm total length (TL) and had not reached maturity. Most sauger captured in headwater areas were mature (greater than 400 mm TL). Sauger W_r of 100 indicates average condition. Age and growth calculations indicated a slightly below average rate up to age two and a substantially increased rate in fish older than two years (figure 10).

Fort Loudoun Reservoir historically supported a large sauger population and an excellent winter and spring fishery in the French Broad River. This fishery has declined in recent years (Dave Bishop, personal communication), and data collected during this study indicated a reduced population. Adult sauger were not collected in large numbers as expected considering their vulnerability to gill netting in the more restricted areas of the river. Also, young sauger were not collected in rotenone samples as in past years.

The demise of the sauger fishery below Douglas Dam is presumed to be the result of lower population levels in Fort Loudoun and/or Douglas

Reservoir (Hevel and Hickman 1985). The collection of both adult and juvenile sauger during this investigation leaves room for optimism that this fishery may recover with improvement in water quality, changes in flow regime, or other potential limiting factors. However, numbers were precariously low and may still result in total loss of the sauger population.

White Bass

A total of 207 white bass was captured from Fort Loudoun Reservoir. The majority (181) were collected by electrofishing and experimental gill netting during the spawning migration in March and April in the French Broad and Holston Rivers. Late spring electrofishing in the three sections of the reservoir captured only two white bass, one each in the middle and lower areas. Summer gill netting captured only 15 white bass, 5 at mid-lake and 10 from the lower section. The remaining nine were collected in fall trap net samples with five from the lower and four from the middle sections of Fort Loudoun Reservoir. Length frequency indicates both juvenile and adult white bass were captured (figure 11).

A PSD index of 81 percent was calculated from the Fort Loudoun white bass length frequency data. This value is well above the 40 to 70 percent range suggested by Anderson (1980) indicating a recruitment problem for these stocks. However, this interpretation is based on the assumption that the sample is representative of the size structure of the population. It is doubtful that the sample adequately represented yearling white bass since most fish collected on the spawning "run" were adults. A low W_r value (94) for Fort Loudoun white bass suggests poor condition for this species although growth is approximately the same as other white bass populations (figure 12).

Channel Catfish

A total of 187 channel catfish was captured in gill nets (58), electrofishing (117) and trap nets (12). The largest sample came from mid-lake (67) followed by the lower (45) and upper (28) sections. Spring sampling in the tributary rivers accounted for the other 47 catfish. Length frequency of catfish captured indicated low numbers of juveniles and higher densities of adults (figure 13), however, only 58 channel catfish were captured with gill nets too few to make PSD and RSD calculations. Other sampling methods were considered size biased, therefore PSD and RSD values were not calculated.

A reservoir wide W_r value of 101 indicates Fort Loudoun channel catfish to be near average. Channel catfish collected from the tributary rivers (103) and lower reservoir section (103) had higher Wr values than those from the upper (99) and mid-reservoir (98) areas. In addition, W_r values were calculated for channel catfish collected for PCB analysis during summer 1985 (figure 14). High W_r's were again evident in the lower and headwater sections of the reservoir with lower W_r's in the mid-lake and upper reservoir areas. Little River embayment had the lowest W_r (83) for the entire reservoir. W_r's of channel catfish collected downstream of the mouth of the Little River in Fort Loudoun Reservoir, for the most part, progressively increased. Increasing Wr's both upstream and downstream of the mouth of Little River suggests water quality in the vicinity of Little River is impacting the relative well-being of catfish in this area. Total reservoir growth rate was greater than average in Tennessee River mainstream reservoirs (figure 15).

Channel catfish are abundant and the most important "nongame" species in the reservoir, being sought by both sport and commercial fishermen. In recent years, levels of PCBs in catfish flesh from Fort Loudoun have caused concern as a public health hazard. Because concentrations in edible flesh exceeded FDA limits in a large portion of samples taken in early 1982, the Tennessee Department of Water Management issued a public advisory in March 1982 recommending against regular consumption of catfish from Fort Loudoun (TVA 1985). Contamination of catfish and other commercial species (i.e., buffalo) represents a significant loss to the fishery.

Creel

Rate of harvest (catch per hour) from Fort Loudoun Reservoir creel data for four consecutive years (1980-1984) ranged from 0.55 per hour in 1983/84 to 1.01 in 1980/81 (table 7). White crappie were harvested at the highest average rate (0.43 per hour) followed by bluegill (0.16), largemouth bass (0.07), channel catfish (0.02), and white bass (0.02). Other species were harvested at an overall rate of less than 0.02 fish per hour.

Total harvest rates and fishing effort decreased from 1980/81 to 1983/84 (figure 10). These parallel trends could be due to increases in fish stocks as a result of recruitment of young fish, especially largemouth bass, in the 1980 and 1981 creel years from newly formed Tellico Reservoir Dam, which was closed November 1979. Rainbow trout, previously not reported from Fort Loudoun but abundant in Tellico, also began showing up in the Fort Loudoun creel after the canal between the two reservoirs was opened.

Harvest rates calculated (table 8) estimated hours expended for fishermen seeking a preferred species revealed anglers fishing for sunfish were the most successful (2.35 sunfish per hour) followed by crappie (1.18), white bass (1.04), rough fish (0.43), catfish (0.29), and black bass (0.19).

Most of the overall effort was expended by fishermen specifically seeking crappie, black bass and those out to catch any species (figure 10). Estimated hours expended by crappie fishermen decreased gradually over the creel period. Black bass effort remained fairly stable with a slight peak in 1981/82. Pressure by the non-specific angler also decreased from 1980 to 1984. Fishing pressure exerted for any other particular species was consistently low throughout the creel period.

Declining harvest rates for crappie anglers was proportional to decreasing pressure. Most of the crappie harvested in Fort Loudoun were white crappie (97 percent); therefore, it is unlikely either crappie harvest or pressure was influenced by inflow of crappie from newly formed Tellico Reservoir since black crappie are the dominant species in Tellico (TVA-TWRA unpublished rotenone data). The higher crappie harvest and pressure in the early 1980's was more likely due to a strong year class naturally produced in Fort Loudoun which gradually phased out of the population by 1984.

Largemouth bass, however, being less sedentary in nature and under a somewhat restricted food supply in Tellico, probably did migrate in large numbers into the more eutrophic Fort Loudoun through the Tellico-Loudoun canal. Increased numbers of largemouth bass caused the increased harvest rate and pressure exerted toward largemouth during 1980-1981 and 1981-1982 fishing seasons. This hypothesis is supported by the average size of bass harvested increasing from 0.76 pounds in 1980-1981 to 1.5 pounds in 1983-1984. Pressure and harvest returned to more normal levels by 1984 after this unusual "stocking" of young bass. Another explanation for the high catch rates of small bass in 1980 is that a large year class of bass was produced naturally in Fort Loudoun.

TWRA Exploitation Rate Investigations

Tennessee Wildlife Resources Agency (Doug Peterson, personal communication) reported that the annual percentage of tagged largemouth bass captured by anglers (i.e., exploitation rate) from Fort Loudoun Reservoir during 1981 and 1982 remained relatively low, 28 and 19 percent respectively. Several authors (Kimsey 1957, La Faunce 1964 and Redmond 1974) have stated that a harvest of up to 40 percent of the adults is not detrimental to the overall population. It is apparent from these data that the largemouth bass population of Fort Loudoun was not harvested excessively during the 1981-1982 period.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Fort Loudoun fish populations were typical of an average mainstream Tennessee River impoundment. Cove rotenone sampling in 1984 yielded a total of 34 species. Gizzard shad and threadfin shad dominated standing stocks (either total numbers or biomass). Standing stock estimates in 1984 were similar to previous years with the exception of a sizeable decline of sauger numbers and biomass.

Largemouth bass had a temporary recruitment problem with low numbers of two-year-old fish and virtually no yearlings. However, there were high numbers of young-of-year individuals in cove rotenone samples. There was also a high number of four-year-old fish suggesting that the impoundment of Tellico Reservoir in 1979 contributed significantly to the Fort Loudoun black bass population. RSD's were relatively high but were driven primarily by the strong age four year class. As this year class contributes to the fishery, fishing should be excellent; however, with no large year classes following, angler success will decrease considerably. Field observations indicated a considerably higher incidence of external lesions and infections on largemouth bass in the upper area of the reservoir than in either the middle or lower areas. The high bacterial loads (as indicated by high coliform levels) and other water quality problems in upper Fort Loudoun are probably responsible for these skin disorders.

Smallmouth bass were concentrated primarily in the lower two-thirds of the reservoir. Both PSD's and RSD's were good and their growth was slightly higher than in other mainstream reservoirs. A strong 1983 year class was present and should provide good fishing through 1986.

Sample size was too small to calculate PSD and RSD for Fort Loudoun white crappie. Growth and condition was lower than the average for Tennessee River mainstream impoundments, indicating some problem which should be investigated.

Fort Loudoun historically supported a large sauger fishery both in the reservoir and in the French Broad River below Douglas Dam. This fishery has declined in recent years, and 1983 samples supported this observation. After normal sampling effort, and additional netting specifically for sauger, only 30 individuals were captured. Of these, both juveniles and adults were represented, leaving room for optimism that the fishery could recover if limiting conditions were eliminated. Without immediate action total loss of this sauger population is anticipated.

White bass were sampled in the headwater areas during the spawning migration (primarily French Broad River) and size distribution probably did not accurately represent the population. PSD index was extremely high, indicating a recruitment problem, but sampling biases for adult fish may have contributed to the inflated percentage. A low W_r value suggests poor condition of white bass when compared to other tributary reservoirs. This low condition factor may be due to the effects of water quality on specific life stages of white bass or the lack of suitable size forage at certain stages during their growth.

Channel catfish are abundant throughout the reservoir but are only sought by five percent of sport fishermen. A reservoir-wide W_r value of 101 suggests that channel catfish are near average for Tennessee River mainstream reservoirs. However, catfish sampled in the Little River embayment of the reservoir had a low W_r (83), indicating a potential problem, perhaps water quality related. Due to recently discovered high PCB levels, consumption of channel catfish has been discouraged. If this problem persists, a valuable part of the Fort Loudoun fishery will be lost.

Creel data were collected from Fort Loudoun for four consecutive years (1980-1984). Harvest rate and total effort exhibited downward trends over the four-year period with highs in 1980 and lows in 1984. This trend could have been due to unusually large fish stocks as a result of recruitment of young fish, especially largemouth bass, through the canal connecting Fort Loudoun to the newly impounded Tellico Reservoir in 1979. As this expanded fish stock disappeared from the reservoir in 1982, 1983, and 1984, pressure decreased. Creel data also showed that no sauger were creeled during the four-year period, substantiating findings of the sampling effort.

Recommendations

Problems confronting biologists on Fort Loudoun Reservoir require actions that can only be taken in coordination with other elements of the scientific community. Many issues involve nonbiological components and only agencies responsible for these components can take appropriate actions. The following areas require attention:

1. The major issue of concern in Fort Loudoun involves water quality and the effects on various components of the fisheries community. High incidences of bacteriological infection in the upper region of the reservoir directly impacts the well-being of individual fish and may affect the willingness of anglers to consume fish. This issue should be investigated to determine if bacteriological contamination is the cause, and if so, solutions should be formulated.
2. Long-term effects from chemical pollutants are also of major concern, and although they may or may not affect fish populations directly, contaminants do affect consumption and use by sport fishermen as well as commercial fishermen and their customers. The significance of PCB contamination in catfish and other species in the reservoir is presently being addressed and monitoring should be continued to assess trends in concentration levels.
3. Sauger have historically provided a valuable fishery and their recent decrease has had significant impact on sport fishing in the reservoir and in the French Broad River. Further investigations involving water level manipulation, flow patterns, and water quality should be implemented to determine causes of sauger demise. After corrective actions are taken, supplemental stocking of this valuable sportfish may be needed to replenish reproductive stocks. As a first step in this area, 50,000 fingerling sauger will be stocked in Douglas tailwater by TVA in 1986, and bioassays will be conducted to identify toxicity to sauger larval.
4. Evaluation of the Fort Loudoun catfish population indicates a growth limiting agent(s) in the Little River embayment area. Further studies to identify causes of this problem should be considered, at which time solutions may be recommended.

5. High numbers of four-year-old, and young-of-year largemouth bass coupled with the lack of one- and two-year-olds indicate a temporary or sporadic recruitment problem. Fishing success for largemouth bass depends primarily on survival of young-of-year through the first winter into the yearling stage. Data to determine recruitment success and causes for absent year classes should be gathered annually to supply sound information. If recruitment failures continue, stocking should be considered as should habitat manipulation to promote survival.
6. White bass have continually declined in condition with the steady increases of yellow bass and yellow perch. Relationships among these species is an academic rather than management issue and should be evaluated by the academic community.
7. Depressed year-class strength and poor condition of white crappie, when compared to white crappie populations in other Tennessee River mainstream impoundments, suggest a persistent problem. Origin and nature of this problem is unknown and should be investigated.

Fort Loudoun Reservoir is located in the center of a large population center and has all the ingredients to supply a highly productive sport fishery. With proper management of these ingredients this fishery may be realized. Correction of the problems and concerns identified in this report will result in increased fishing activity and greater satisfaction of the fishing public than presently exists on Fort Loudoun Reservoir.

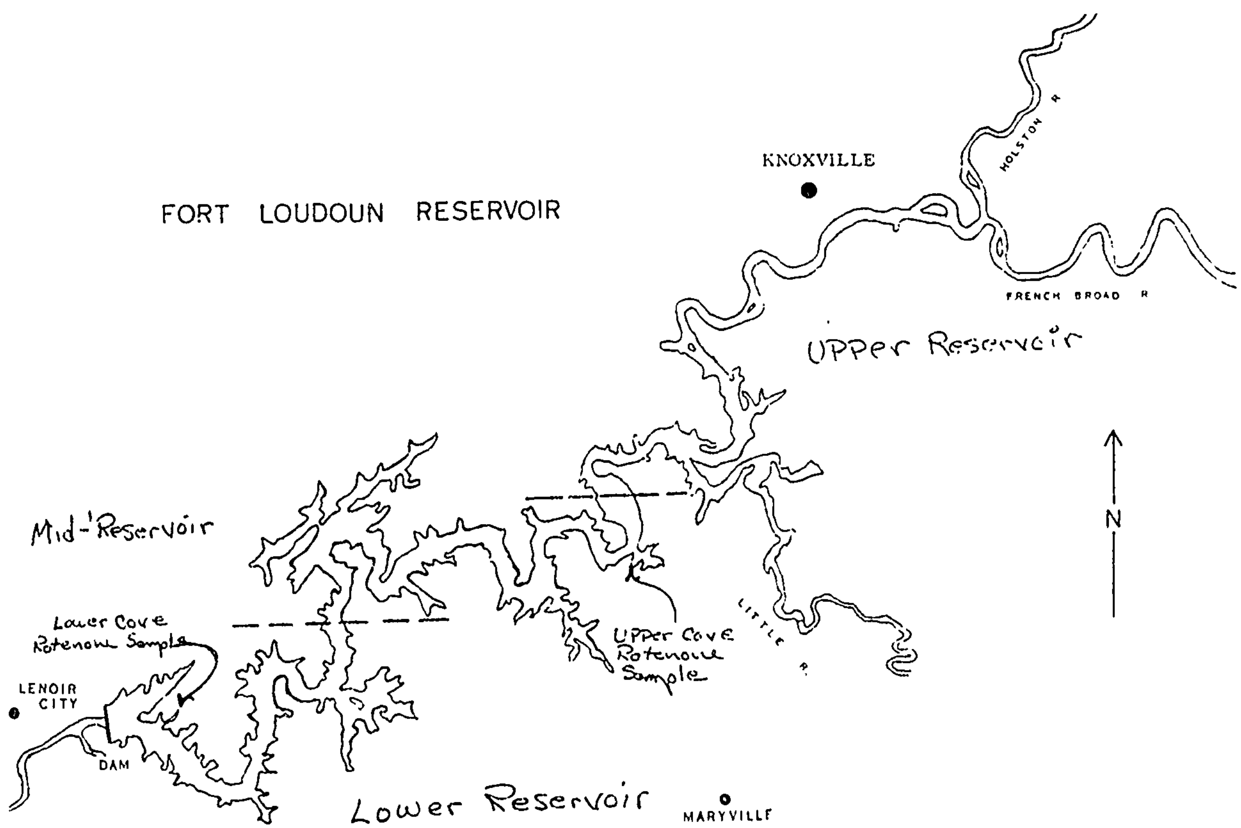


FIGURE 1. LOCATIONS OF ROTENONE SAMPLE COVES AND NETTING/ELECTROFISHING SECTIONS IN FORT LOUDOUN, 1984.

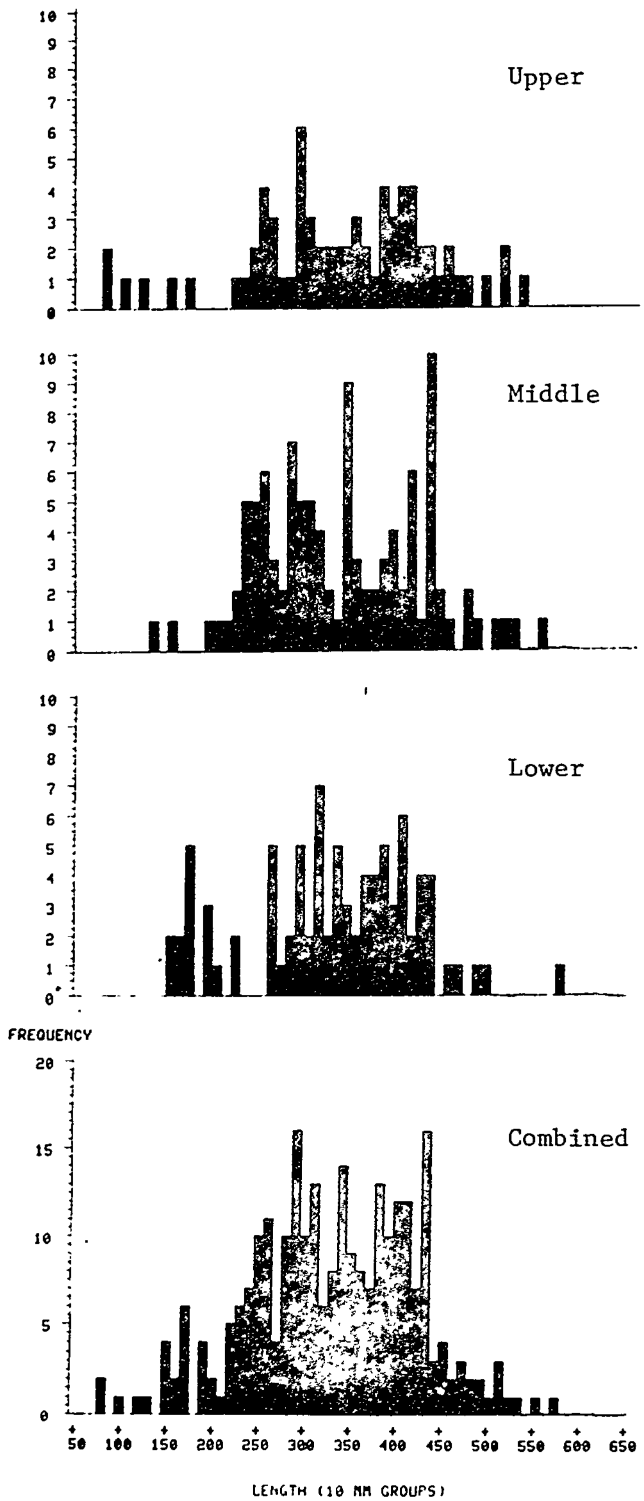


Figure 2. Largemouth bass length frequency, Fort Loudoun Reservoir, 1984.

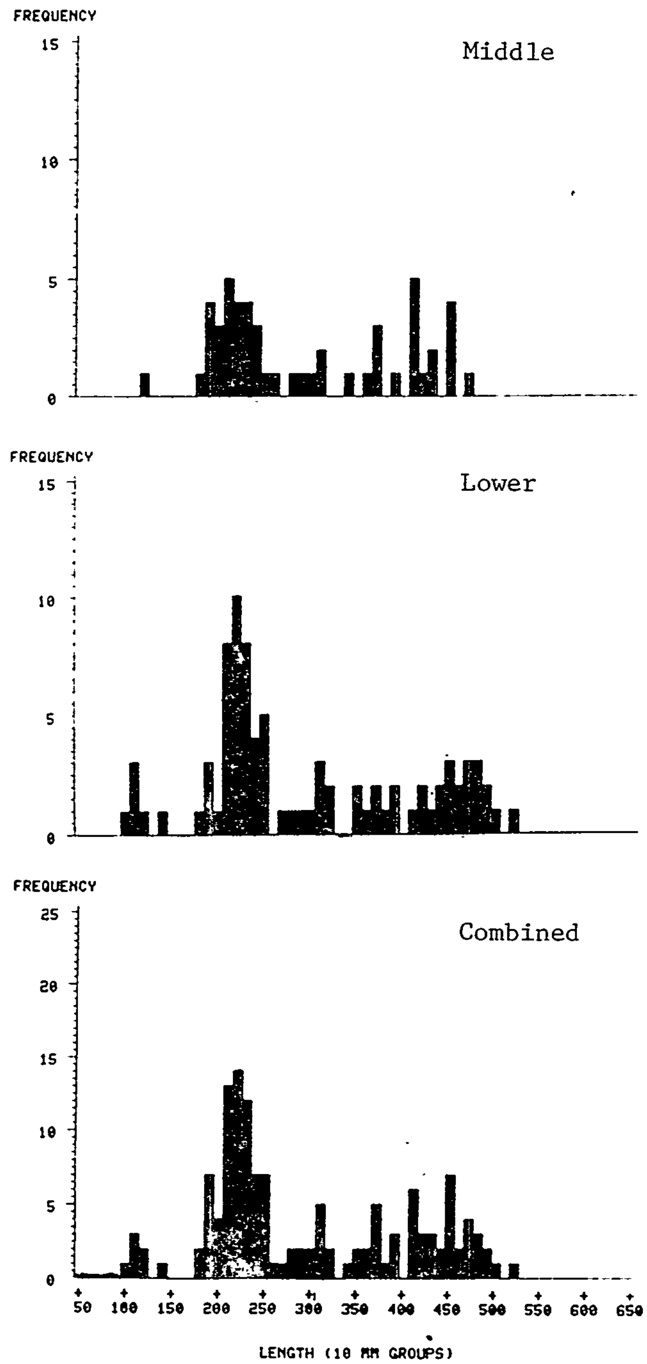


Figure 3. Smallmouth bass length frequency, Fort Loudoun Reservoir, 1984.

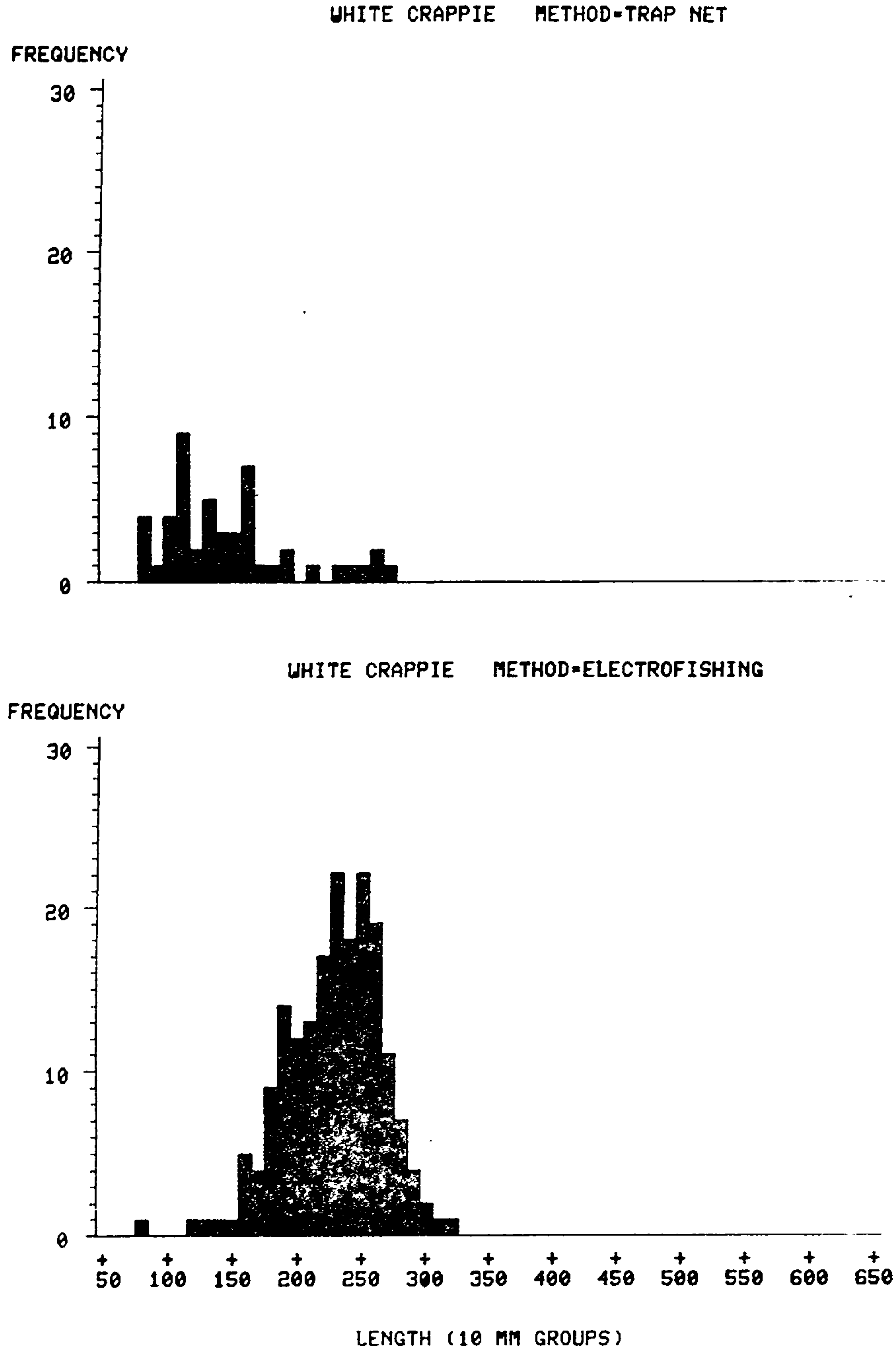


Figure 4. Length frequency of white crappie captured in trap nets and by electrofishing in Fort Loudoun Reservoir, 1984.

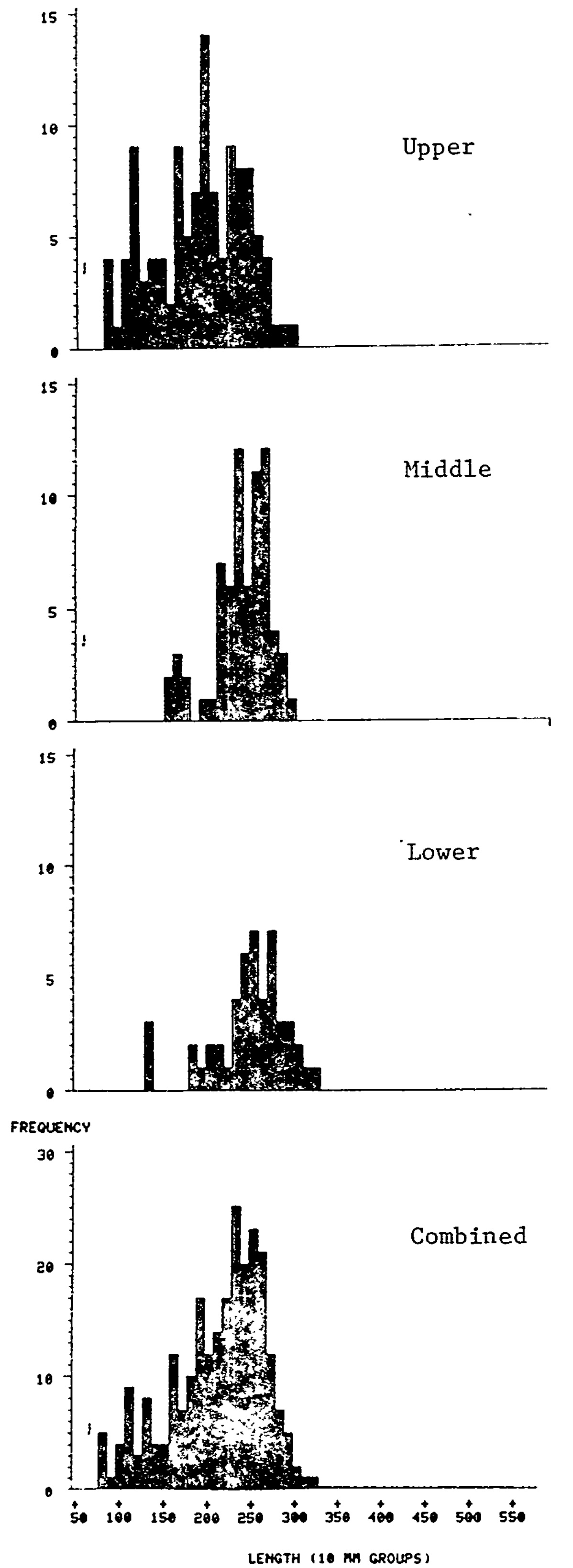


Figure 5. White crappie length frequency, Fort Loudoun Reservoir, 1984.

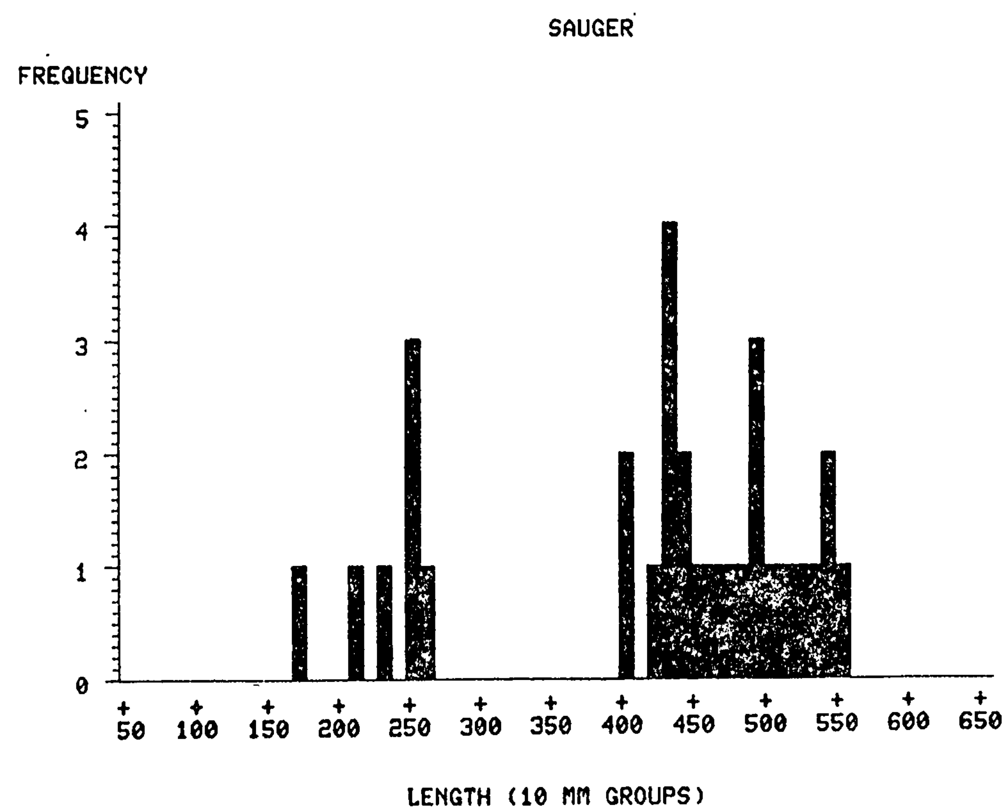


Figure 6. Length frequency of sauger captured in Fort Loudoun Reservoir, 1984.

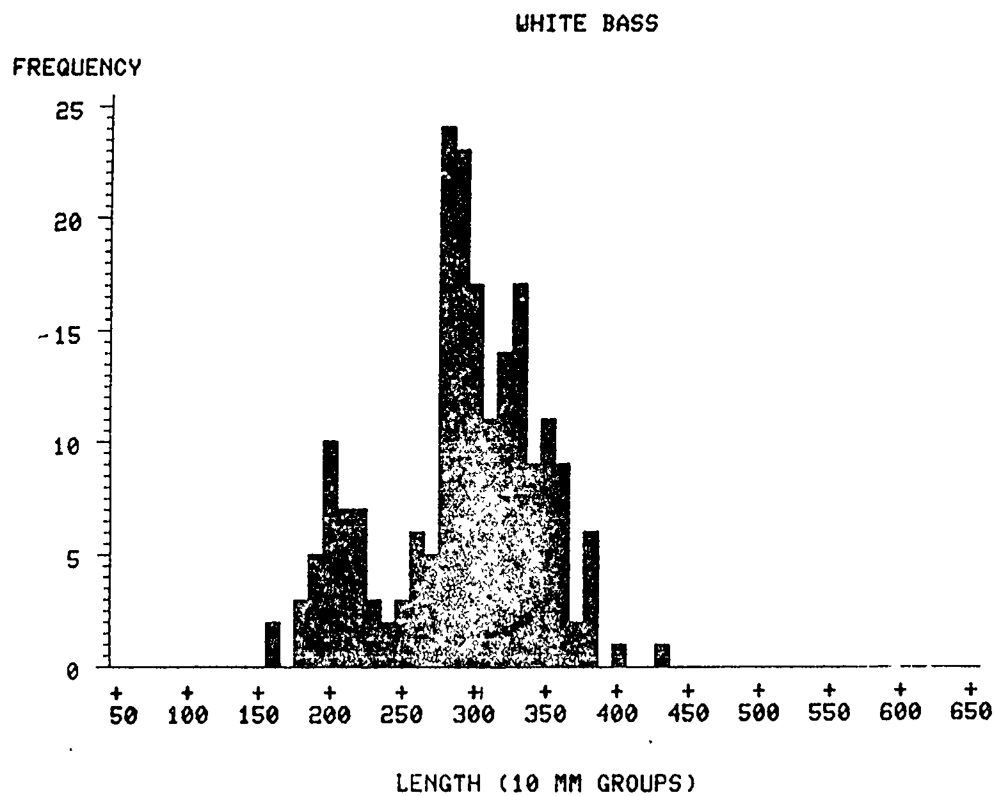


Figure 7. Length frequency of white bass captured in Fort Loudoun Reservoir, 1984.

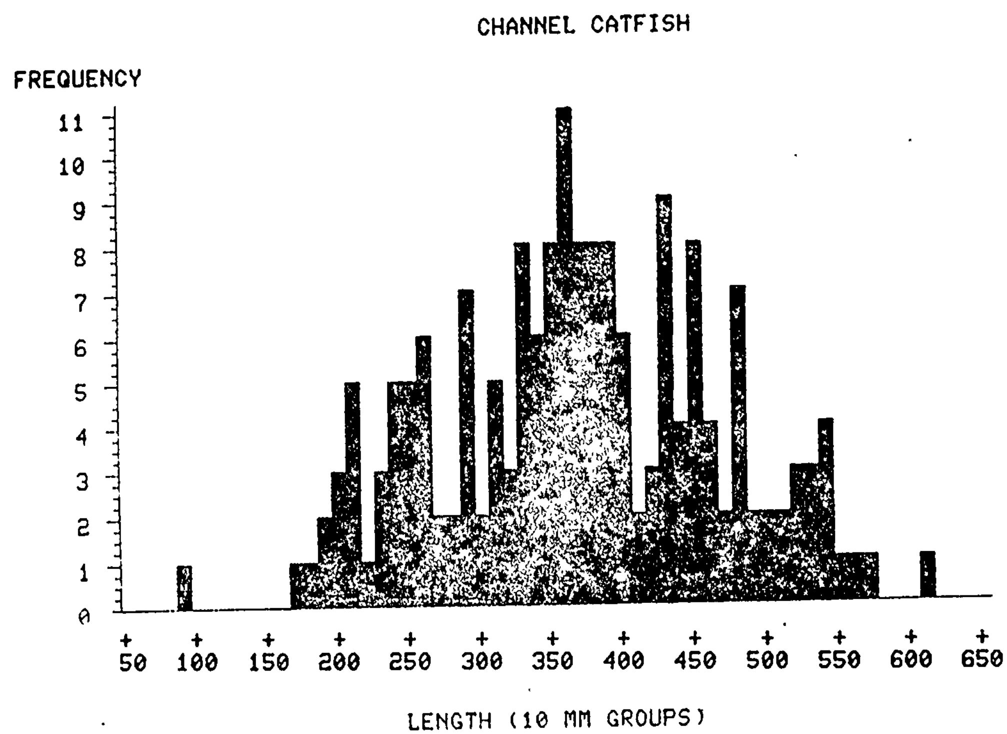


Figure 8. Length frequency of channel catfish captured in Fort Loudoun Reservoir, 1984.

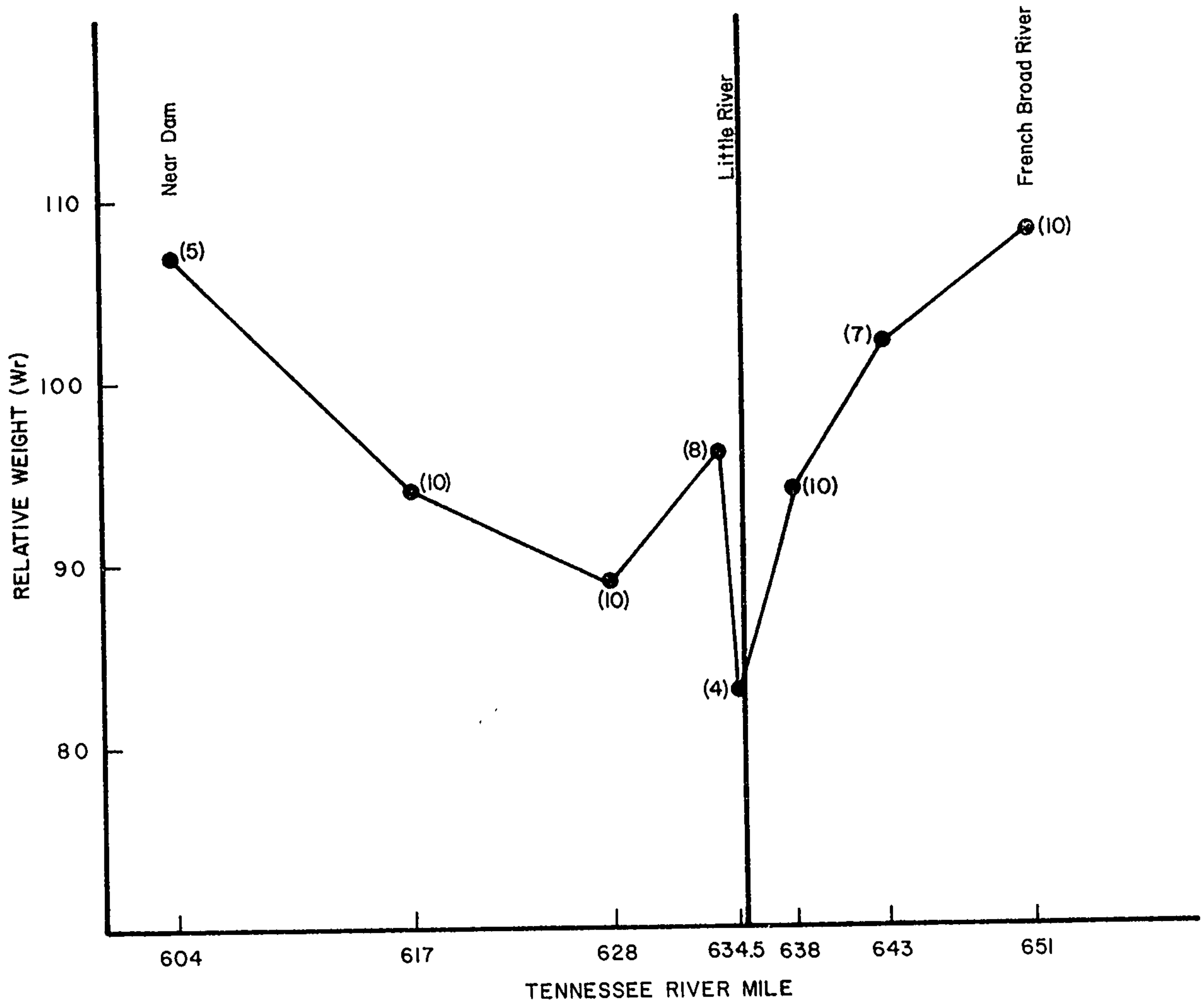


Figure 9. Mean relative weight values for channel catfish collected from various locations in Fort Loudoun Reseroivr (number of fish in parenthesis).

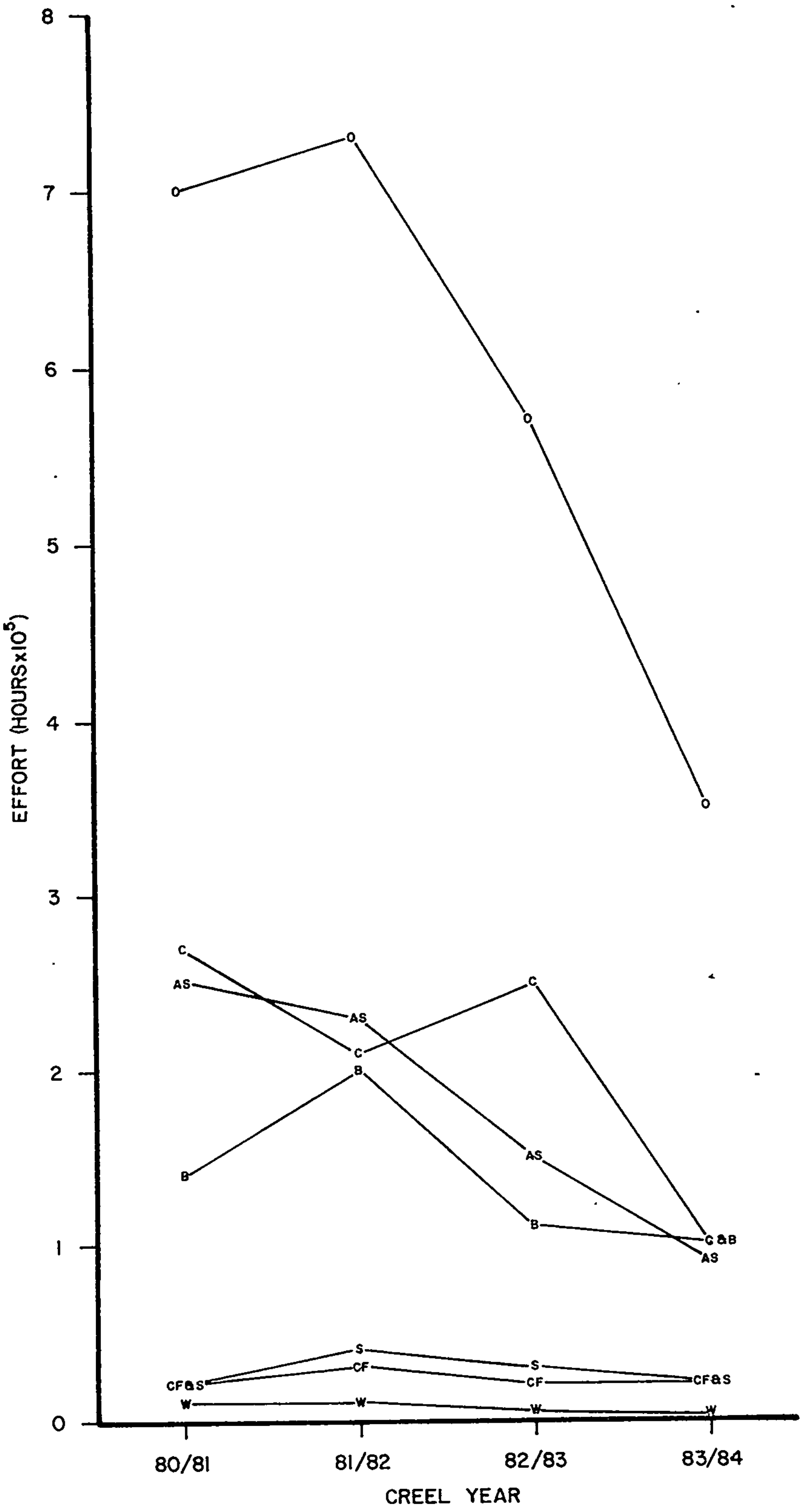


Figure 10. Overall and species intended fishing effort on Fort Loudoun Reservoir for creel years 1980-1984 (O = overall, C = crappie, B = black bass, AS = any species, CF = catfish, S = sunfish, and W = white bass).

Table 1. Proposed Total Lengths (mm) for Stock, Quality, Preferred, Memorable, and Trophy Sizes of Various Fish Species Based on Percentages of World Record Length (from Gabelhouse 1983)

			Size Designation		
Species	Stock	Quality	Preferred	Memorable	Trophy
Largemouth bass*	200	305	380	460	570
Smallmouth	180	280	350	430	510
Spotted bass	180	280	350	430	510
Walleye	250	380	510	630	760
Sauger	200	300	380	510	630
Blue catfish	300	510	760	890	1140
Channel catfish	280	410	610	710	910
Flathead catfish	280	410	610	710	910
Bluegill	80	150	200	250	300
Black crappie	130	200	250	300	380
White crappie	130	200	250	300	380
White bass	150	230	300	380	460
Yellow bass	100	180	230	280	330
Smallmouth buffalo	280	410	530	660	840
Gizzard shad	180	280	-	-	-

*Based on percentages of Tennessee State record largemouth since world record was Florida subspecies.

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Table 2. Results of Cove Rotenone Sampling in Fort Loudoun Reservoir, August 1984

	Young of Year		Intermediate		Harvestable		Total	
	Number	Biomass	Number	Biomass	Number	Biomass	Number	Biomass
Threadfin shad	13344.89	30.93	-	-	4.93	0.10	13349.82	31.03
Gizzard shad	5151.30	12.51	-	-	2207.34	92.60	7358.64	105.12
Bluegill	871.75	1.99	1079.84	18.37	278.91	14.94	2230.49	35.30
Bullhead minnow	622.66	0.84	-	-	-	-	622.66	0.84
Freshwater drum	50.86	0.72	364.90	12.76	97.03	15.46	512.79	28.94
Yellow bass	337.09	1.55	9.58	0.54	1.36	0.19	348.04	2.28
Warmouth	188.91	0.68	67.58	0.99	7.04	0.38	263.53	2.04
Largemouth bass	160.98	0.64	35.17	1.34	11.13	4.48	207.28	6.46
Green sunfish	161.84	0.24	28.95	0.37	0.66	0.03	191.45	0.64
White crappie	11.97	0.02	71.13	2.63	67.10	7.27	150.19	9.92
Carp	-	-	47.41	11.99	70.22	46.95	117.62	58.94
Channel catfish	17.24	0.09	22.22	1.10	56.54	18.45	96.01	19.64
Redbreast sunfish	25.60	0.05	20.95	0.29	31.38	2.25	77.94	2.59
Smallmouth bass	40.79	0.18	5.26	0.30	2.63	0.57	48.68	1.05
Spotfin shiner	37.17	0.08	-	-	-	-	37.17	0.08
Logperch	35.93	0.27	-	-	-	-	35.93	0.27
White bass	32.24	0.22	2.07	0.12	-	-	34.30	0.34
Yellow bullhead	21.60	0.07	5.45	0.17	6.90	1.45	33.95	1.69
Smallmouth buffalo	-	-	3.52	0.71	29.04	21.29	32.56	21.99
Brook silverside	18.79	0.02	-	-	-	-	18.79	0.02
Golden shiner	16.49	0.05	-	-	-	-	16.49	0.05
Redear sunfish	-	-	2.82	0.05	11.97	0.60	14.79	0.65
Yellow perch	-	-	11.84	0.07	2.63	0.09	14.47	0.16
Blackspotted topminnow	14.08	0.02	-	-	-	-	14.08	0.02
Skipjack herring	7.51	0.07	2.11	0.07	-	-	9.63	0.13
Black buffalo	-	-	-	-	7.61	8.16	7.61	8.16
Emerald shiner	6.58	0.03	-	-	-	-	6.58	0.03
Flathead catfish	2.63	0.01	-	-	2.72	1.45	5.36	1.45
Northern hogsucker	0.66	0.03	3.29	0.27	0.66	0.13	4.61	0.43
Unidentified carpsucker	3.52	0.01	-	-	-	-	3.52	0.01

Table 2. (Continued)

	Young of Year		Intermediate		Harvestable		Total	
	Number	Biomass	Number	Biomass	Number	Biomass	Number	Biomass
Black crappie	-	-	0.66	0.03	2.11	0.37	2.77	0.40
Sauger	-	-	-	-	2.68	0.66	2.68	0.66
Longnose gar	1.41	0.03	-	-	-	-	1.41	0.03
Fathead minnow	1.41	T*	-	-	-	-	1.41	T
Total	21,185.90	51.35	1,784.75	52.17	2,902.59	237.87	25,873.25	341.36

*T = Less than 0.01 per hectare.

FAEB-0193h

Table 3. Species Composition of Cove Populations, Fort Loudoun Reservoir, August 1984

Species	Percent of Total numbers	Percent of Total weight
Threadfin shad	51.60	9.09
Gizzard shad	28.44	30.79
Bluegill	8.62	10.34
Bullhead minnow	2.41	0.25
Freshwater drum	1.98	8.48
Yellow bass	1.35	0.67
Warmouth	1.02	0.60
Largemouth bass	0.80	1.89
Green sunfish	0.74	0.19
White crappie	0.58	2.91
Carp	0.45	17.27
Channel catfish	0.37	5.75
Redbreast sunfish	0.30	0.76
Smallmouth bass	0.19	0.31
Spotfin shiner	0.14	0.02
Logperch	0.14	0.08
White bass	0.13	0.10
Yellow bullhead	0.13	0.50
Smallmouth buffalo	0.13	6.44
Brook silverside	0.07	T*
Golden shiner	0.06	0.01
Redear sunfish	0.06	0.19
Yellow perch	0.06	0.05
Blackspotted topminnow	0.05	T
Skipjack herring	0.04	0.04
Black buffalo	0.03	2.39
Emerald shiner	0.03	T
Flathead catfish	0.02	0.43
Northern hogsucker	0.02	0.13
Unidentified carpsucker	0.01	T
Black crappie	0.01	0.12
Sauger	0.01	0.19
Longnose gar	T	T
Fathead minnow	T	T
Total	100.00	100.00

*T = Less than 0.01 percent.

FAEB-0191h

Table 4. Comparison of Number of Individuals Per Species from Fort Loudoun Reservoir 1984 Cove Rotenone Results with Mean Numbers for the Period 1949-1982 in Reservoir Cove Rotenone Samples

Species	Mean 1949-1982	1984
Threadfin shad	12,480	13,350
Gizzard shad	9,581	7,359
Bluegill	1,785	2,230
Freshwater drum	141	513
Yellow bass	0	348
Warmouth	130	263
Largemouth bass	91	207
Green sunfish	105	191
White crappie	124	150
Carp	56	117
Channel catfish	36	96
Redbreast sunfish	37	78
Smallmouth bass	52	49
White bass	90	34
Yellow bullhead	8	34
Smallmouth buffalo	8	33
Redear sunfish	T*	15
Yellow perch	0	14
Skipjack herring	14	10
Black buffalo	0	8
Flathead catfish	17	5
Northern hogsucker	T	5
Black crappie	4	3
Sauger	8	3
Longnose gar	T	1

*T = Less than 0.5 per hectare.

FAEB-0187h

Table 5. Catch Per Unit Effort (Catch Per Net Night) for Species Collected from Four Areas in Fort Loudoun Reservoir, French Broad River, and Holston River using Experimental Gill Nets, Summer 1984 (Number Captured in Parentheses)

Species	Lower Lake	Mid Lake	Upper Lake	Tributary Rivers*
Skipjack herring	3.2(19)	3.3(20)	0.2(1)	1.0(47)
Gizzard shad	29.3(176)	23.5(141)	6.2(37)	0.2(12)
Threadfin shad	7.3(44)	1.5(9)	0.3(2)	–
Mooneye	0.3(2)	0.5(3)	–	0.1(3)
Carp	7.8(47)	2.0(12)	1.2(7)	T(2)
Northern hogsucker	–	–	–	T(1)
Smallmouth buffalo	2.7(16)	0.8(5)	–	–
Shorthead redhorse	–	–	–	T(1)
Blue catfish	1.3(8)	0.3(2)	1.8(1)	–
Black bullhead	0.2(1)	–	–	–
Channel catfish	2.3(14)	3.0(18)	1.8(11)	0.2(15)
Flathead catfish	0.3(2)	–	–	–
White bass	1.7(10)	0.8(5)	–	0.3(36)
Yellow bass	1.5(9)	5.3(32)	–	0.2(22)
Bluegill	0.5(3)	–	0.2(1)	–
Smallmouth bass	0.2(1)	–	–	–
Spotted bass	0.3(2)	–	–	T(2)
Largemouth bass	0.5(3)	–	–	T(1)
White crappie	–	0.5(3)	0.3(2)	T(1)
Sauger	–	–	–	0.1(22)
Walleye	–	–	–	T(1)
Freshwater drum	0.7(4)	0.7(4)	3.5(21)	–
Total	60.2(361	42.3(254)	15.5(93)	2.2(166)

*Tributary rivers sampled in spring 1984.

FAEB-0190h

Table 6. PSD and RSD Values for TWRA and TVA Largemouth Bass Samples During Spring 1977, 1978, 1981, 1982, and 1984

Year	PSD	Preferred	Memorable	Trophy
1977*	36	11	3	0
1978*	72	12	3	0
1981	40	17	-	-
1982	38	13	-	-
1984	66	36	7	0.4

*Data from Sinking and Turkey Creeks only (mid-lake).

FAEB-0189h

Table 7. Harvest Rates (Catch Per Hour) of Fish from Fort Loudoun Reservoir from 1980-1984

Species	Creel Year 1980-1981	1981-1982	1982-1983	1983-1984
Skipjack herring	T*	-	T	.001
Mooneye	T	-	-	-
Rainbow trout	-	-	.001	.001
Common carp	.001	.004	.007	.005
Bullhead	.005	.004	.003	.003
Blue catfish	.001	.002	.002	.002
Channel catfish	.023	.021	.020	.022
Flathead catfish	T	.002	.001	.002
White bass	.026	.025	.016	.009
Yellow bass	.002	.005	.002	.011
Rock bass	.002	.001	.002	.001
Sunfish	.020	.014	.016	.018
Bluegill	.180	.167	.166	.129
Redear sunfish	.005	.004	.001	.006
Smallmouth bass	.008	.011	.007	.007
Spotted bass	.002	.001	.001	.001
Largemouth bass	.080	.108	.040	.040
White crappie	.613	.454	.429	.276
Black crappie	.025	.020	.011	.003
Yellow perch	-	T	-	-
Freshwater drum	.014	.011	.012	.013
Total	1.007	.854	.737	.550

*T = Less than .0001 per hectare.

FAEB-0188h

Table 8. Harvest Rates (Catch Per Hour) of Groups of Fish by Fishermen Specifically Seeking that Group on Fort Loudoun Reservoir from 1980-1984

Species	1980-1981	1981-1982	1982-1983	1983-1984
Crappie	1.66	1.39	.90	.75
Black bass	.25	.25	.15	.12
Sunfish	2.63	2.02	2.57	2.17
Catfish	.15	.45	.31	.24
Rough fish	.36	1.00	.08	.27
White bass	1.16	1.06	1.35	.66

FAEB-0186h

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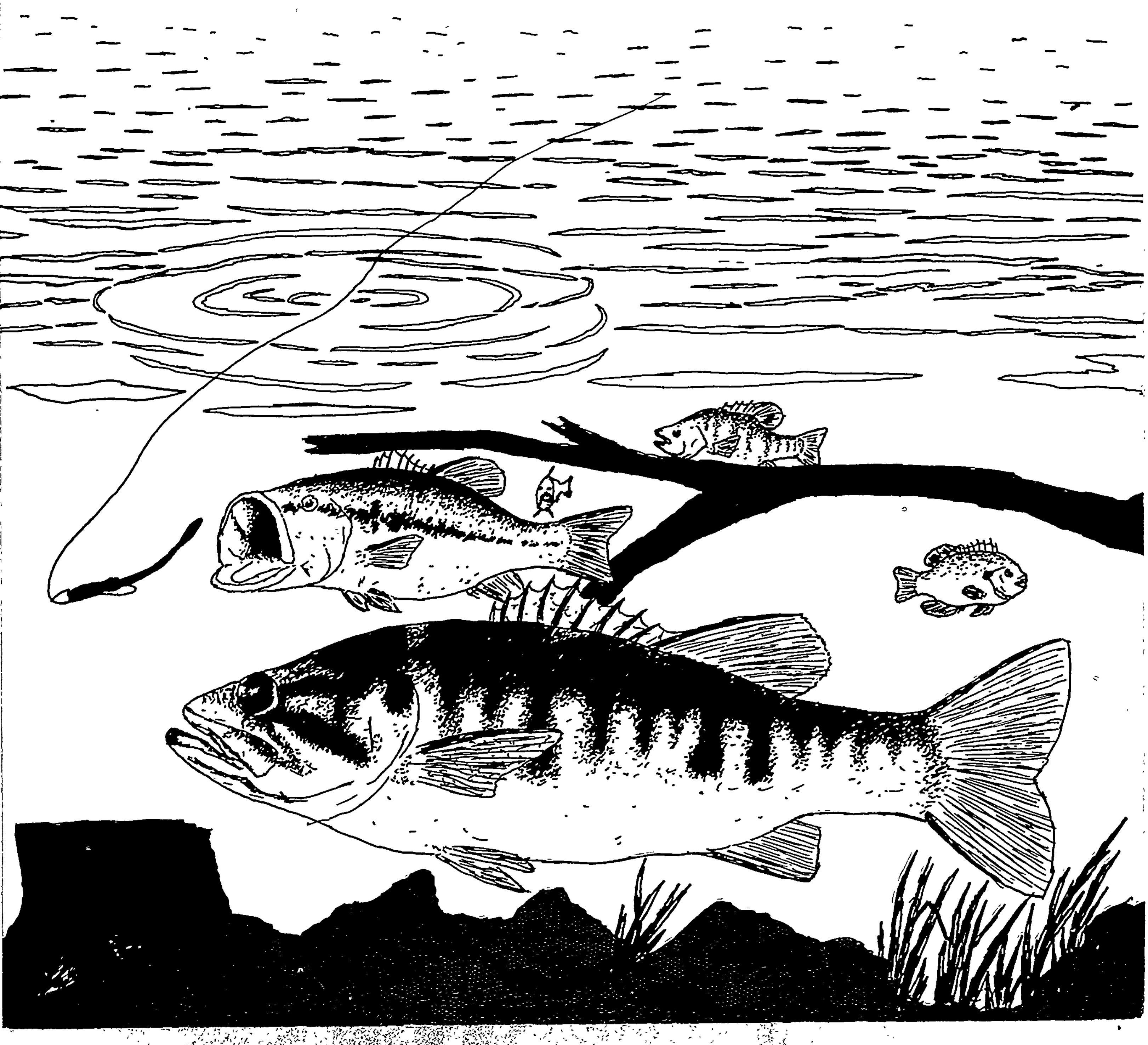
TVA Chattanooga 1/19/93

Fish and Fishing On Melton Hill Reservoir



Fish And Fishing On Melton Hill Reservoir

Melton Hill Reservoir, located on the lower portion of the Clinch River, extends 44 river miles and covers 5,690 acres. It is near three populated areas: Clinton, Oak Ridge, and Knoxville, Tennessee. There are access areas on Melton Hill Dam Reservation and municipal parks where boats can conveniently be launched (see Largemouth Bass Map).

Recent creel data on Melton Hill Reservoir indicate that bass are most sought after by fishermen, with crappie and bluegill running a close second. Good stringers of all three species are common. In the following sections, lures and methods commonly used by successful fishermen who catch these species are described. Maps showing the best fishing areas are provided. Also, a recreation map of Melton Hill Lake is available upon request from TVA's Information Office, Knoxville, Tennessee 37902.

Largemouth Are Usually Taken Near Underwater Structures

Largemouth, smallmouth, and spotted basses are present in the reservoir; however, largemouth are the largest member of the black basses (Figure 1), the most numerous, and the most sought after by fishermen. They usually spawn in the spring when the water temperature reaches 60-68 degrees Fahrenheit. Largemouth usually feed on fish, but are also known to eat insects, crayfish, frogs, mice, leeches, and ducklings.

The preferred habitat of largemouth is submerged structure. They can be found near brush and rock piles, around points with a dropoff, and underwater creek beds, and in areas with irregular bottom types. Melton Hill Reservoir contains extensive beds of aquatic vegetation and most bass are generally taken in or near these heavily vegetated areas (see Largemouth Bass Map).

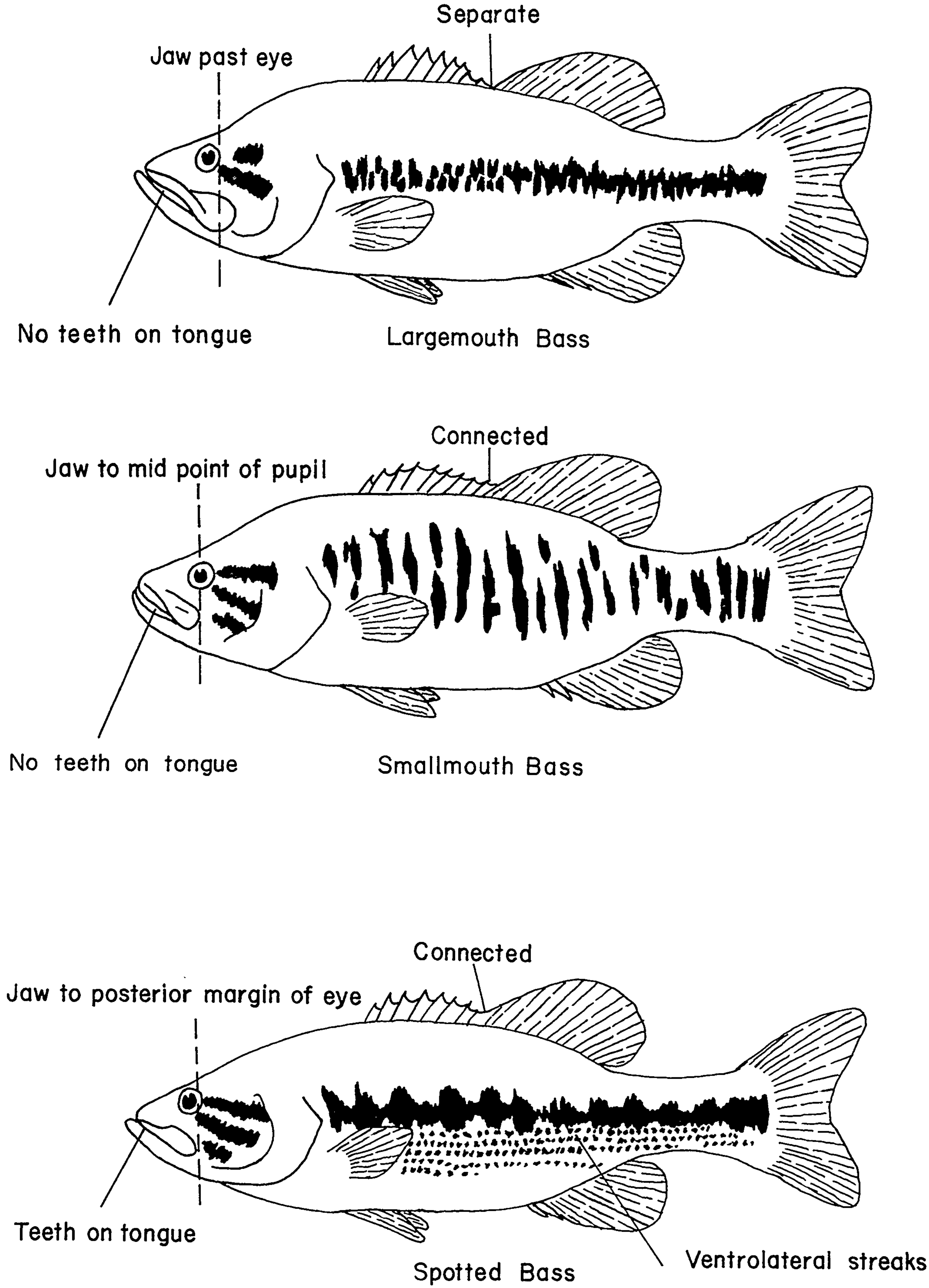
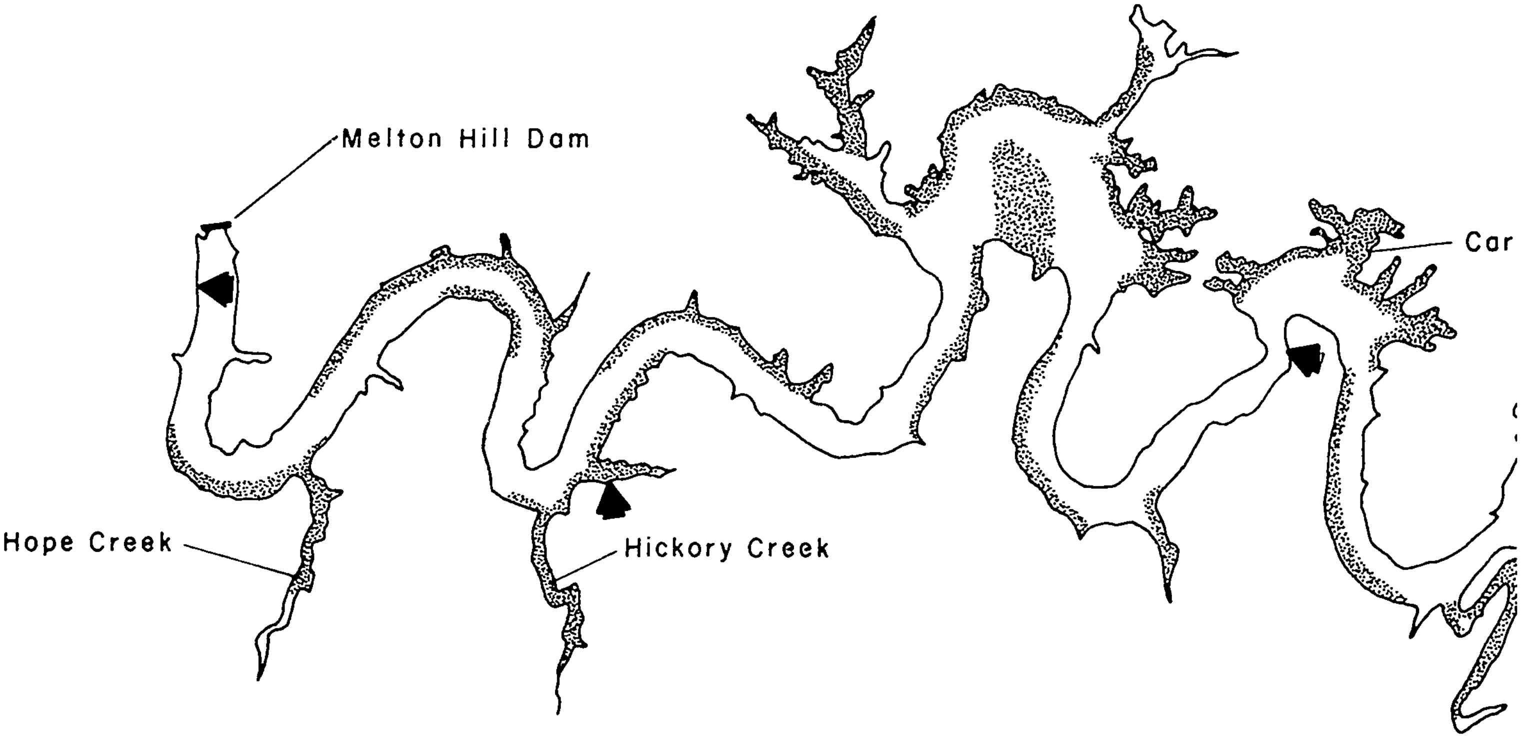


Figure 1. Largemouth, Smallmouth, and Spotted Basses



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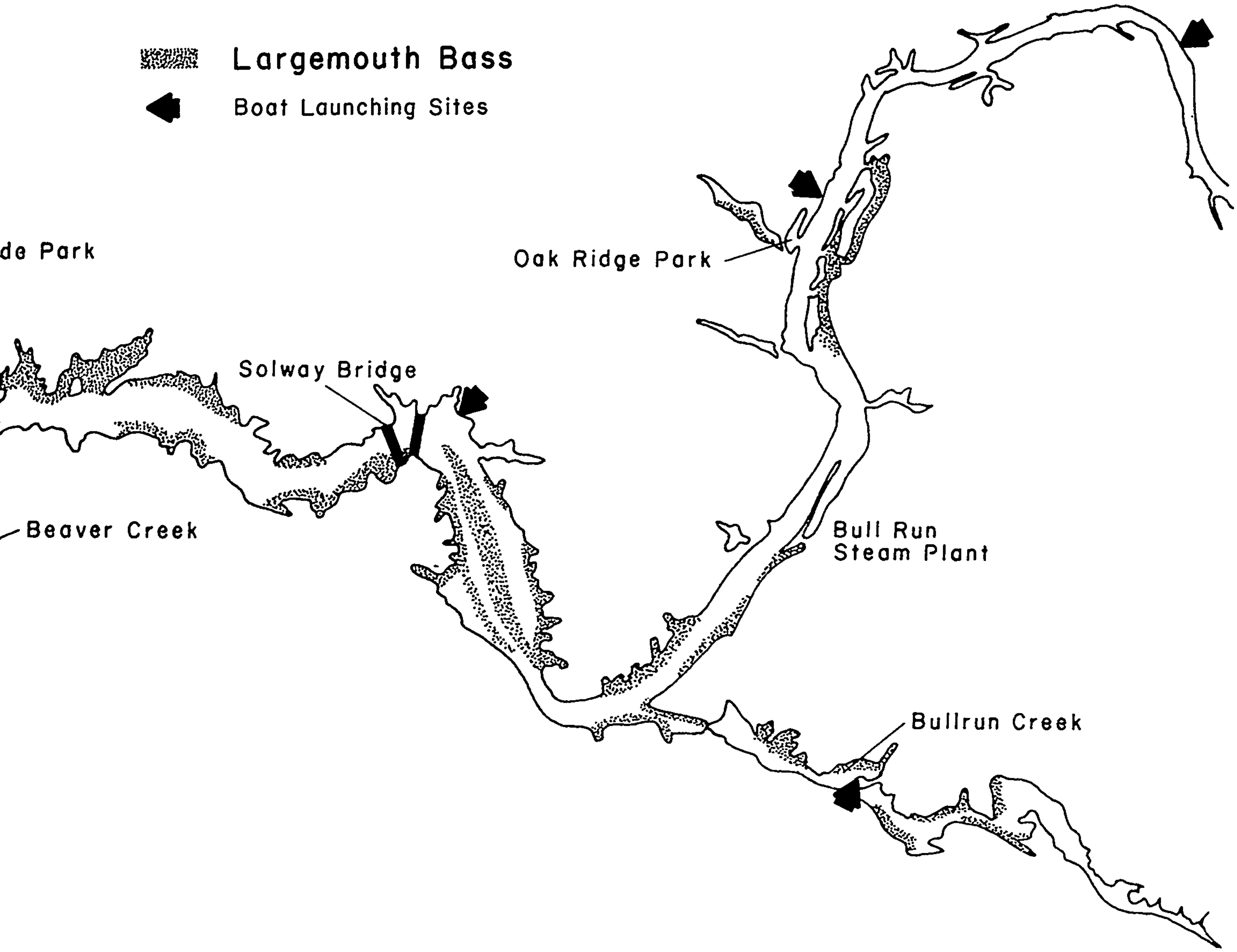

Largemouth Bass
Boat Launching Sites
de Park
Oak Ridge Park
Solway Bridge
Beaver Creek
Bull Run
Steam Plant
Bullrun Creek

Bass Map

The "Texas Rig" May Prevent Snagging

Live baits used to take largemouth include minnows and crayfish. Effective artificial baits include a large variety of surface and underwater lures such as floating and deep running crankbaits, plastic worms, spinner baits, and various jigs (Figure 4.).

Some expertise is needed to successfully use the lures listed above. The artificial worm requires the most time and effort to master. The plastic worm is most often hooked in a "weedless" method with a slip sinker (Figure 5). This arrangement, commonly called a "Texas rig," allows the fisherman to fish in heavy cover with little fear of snagging. The most effective method of fishing with an artificial worm is a slow, pumping retrieve (Fig. 6), allowing the worm to fall to the bottom after each pumping action. A light "tap-tap-tap" is usually the only sign that a bass has picked up the worm. When that happens, allow the bass time to run the slack out of the line, then set the hook with enough power to penetrate the plastic worm as well as the fish's mouth.

Another lure, the sputtering type lure or spinner bait (Fig. 4-A), is an effective lure to use on Melton Hill Reservoir, especially when it is worked over and around the large watermilfoil beds. The retrieve is the most important factor in its use. The lure is cast near the vegetation or brush pile and brought back on or near the surface causing its blade to make a sputtering sound. The strike usually occurs with a jerk and a splash, leaving little doubt about what has happened.

Two other lure types are the crankbait (Fig. 4-B) and the Rapala-type lure (Fig. 4-C). The crankbait is retrieved in a steady motion. Likewise, the Rapala can be retrieved steadily, but the most effective method is to bring the lure back in a short, jerking motion allowing a short interval of time to pass between jerks.

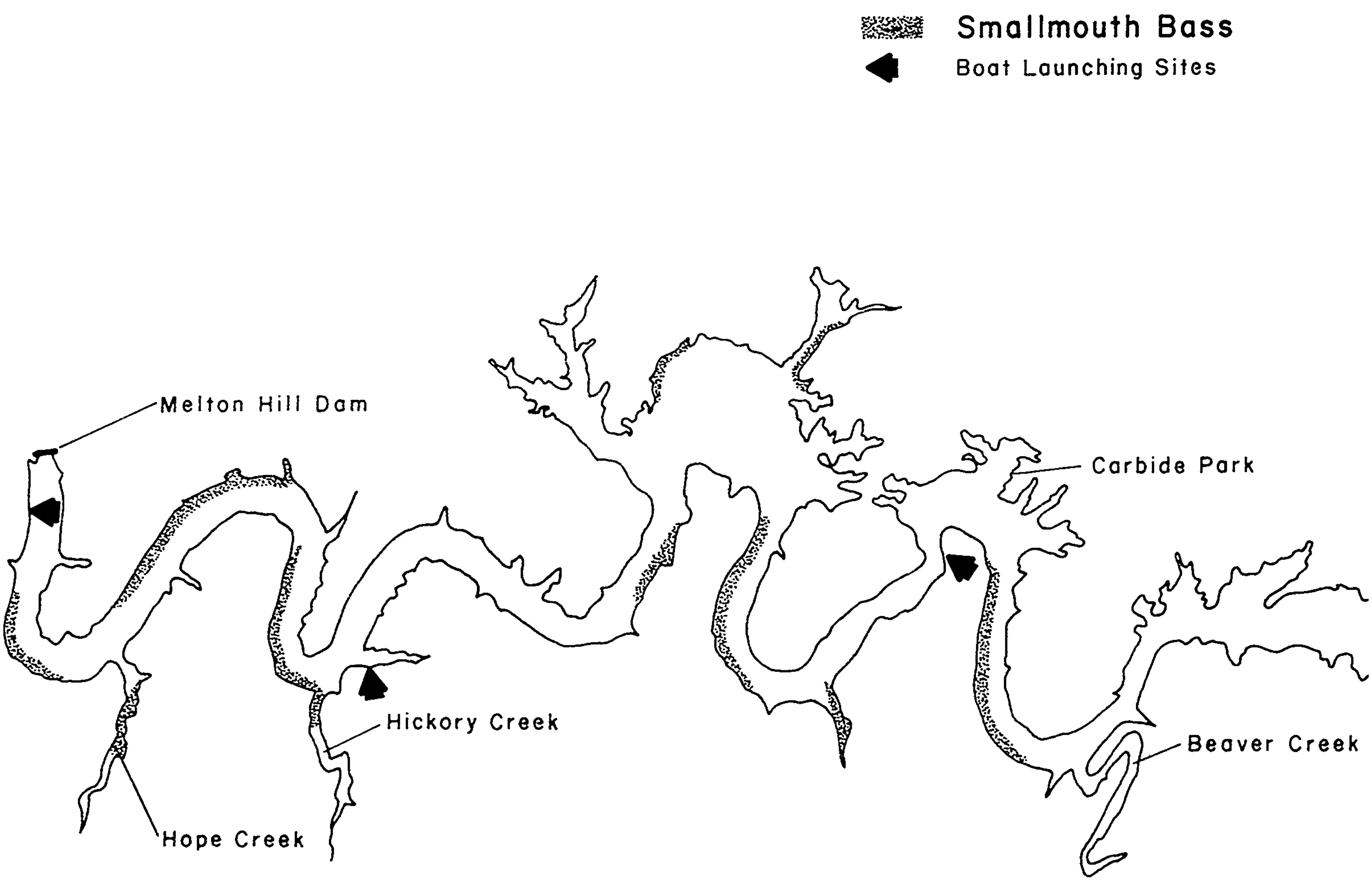
Smallmouth Bass: Correct Line Strength May Determine Whether the Fish or the Fisherman Wins The Struggle

Another species found in Melton Hill Reservoir is the smallmouth bass. The smallmouth bass is considered by many to be the most ferocious fighter of all black basses. This member of the sunfish family is easily distinguished from its two closest relatives, the largemouth and spotted basses. The smallmouth has smaller scales and vertical dark blotches or bars along the side of the fish instead of the horizontal black type characteristic of largemouth and spotted basses (Figure 1). Its mouth extends only to the middle of his eye instead of beyond the back edge. As the water warms to approximately 60 degrees Fahrenheit in the spring, the smallmouth enters shallow water to spawn. Preferred foods include small fish, frogs, crayfish, and large insects.

The favorite habitats of smallmouth are deep, rocky ledges and points. Most of these areas in Melton Hill are found in the lower seven miles of the reservoir (see Smallmouth Bass Map). Best live bait for smallmouth are minnows, crayfish, and salamanders. Preferred artificial baits include spinners (Figure 4-C), crankbaits, small grubs (Figure 4-D), and jigs tipped with pork rind (Figure 4-E). The jig-pork rind and the grub rigs require more skill in use than other artificials. Both types have similar actions, and thus require about the same application in their use. The action of the lure is transmitted from the rod by a slow, pumping retrieve allowing the lure to fall to the bottom after each pumping action (Figure 7).

In most cases the line size plays an important part in smallmouth fishing. In extremely clear water, a four-pound test line may serve best; in more turbid water, a larger line size would be used. Also, the smaller the line size, the smaller the bait should be. For example, a four-pound test line and a 1/32 to 1/8 ounce jig are a good combination, while a 10-pound test line and a 3/8 to 1/2 ounce jig should get good results.

Smallmouth are most available to the angler in the spring (April and May) when they move into shallow water to spawn. They can also be taken during October and November. In addition, night fishing is particularly successful during summer months.

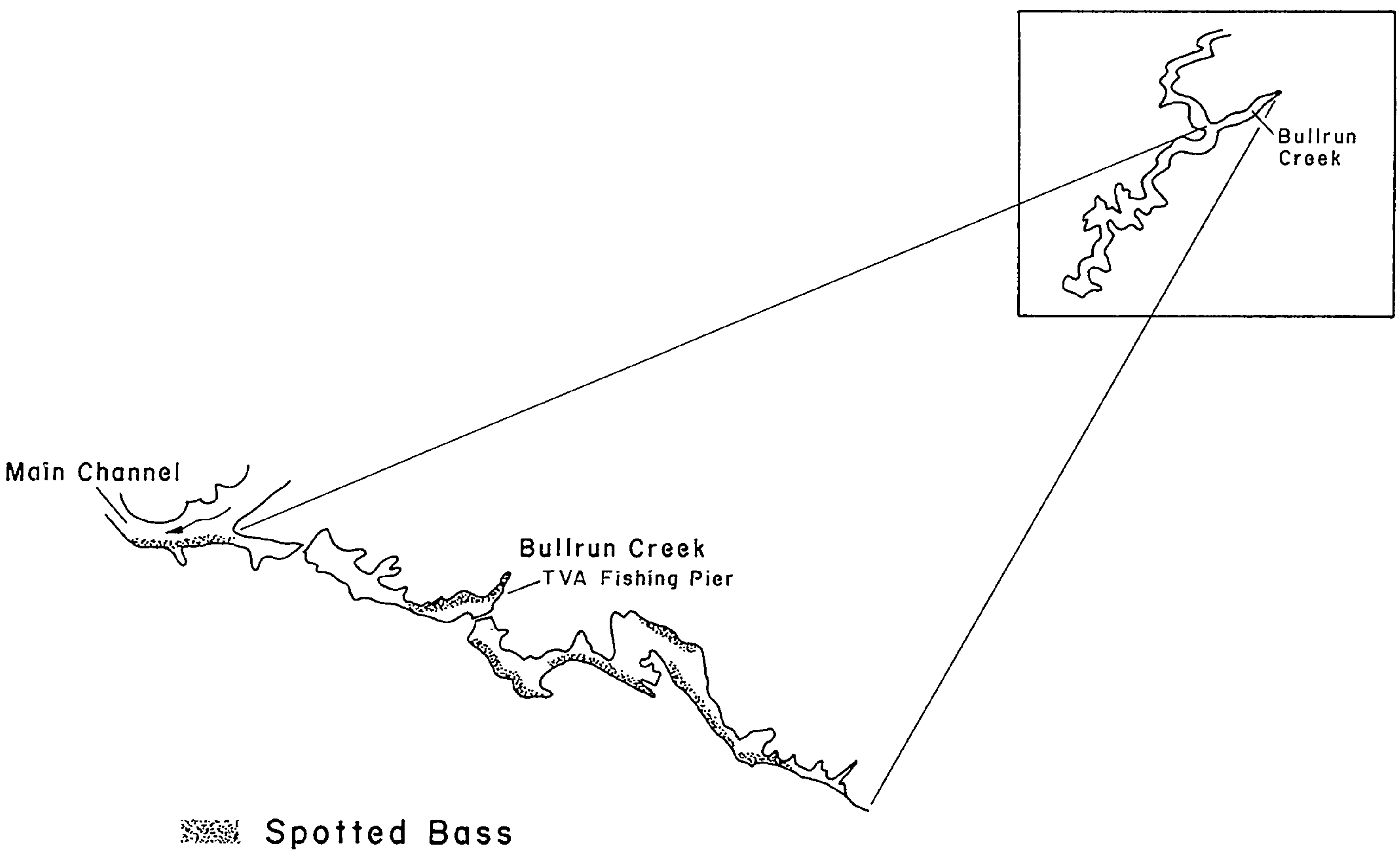


Smallmouth Bass Map

Spotted Bass: The Only Bass With The Rough Tooth Patch On Its Tongue

A species found in Melton Hill Reservoir that is sometimes incorrectly identified as a largemouth is the spotted or Kentucky bass. Spotted bass have body coloration similar to the largemouth, but the rough tooth patch on the tongue distinguishes it from the largemouth (Figure 1). Other characteristics include a shallow notch between the two dorsal fins and evenly arranged rows of dots below the lateral line. Spotted bass spawn in the spring when the water temperature reaches 61 to 62 degrees Fahrenheit. They feed on similar organisms as other basses, and methods used to catch spotted bass are similar to those used to catch smallmouth and largemouth.

Best areas to catch spotted bass in Melton Hill Reservoir are in the Bull Run Creek embayment and off rock banks in the lower end of the reservoir where smallmouth are found.



Spotted Bass Map

Best Bluegill Fishing Is Late Spring and Summer

One of the better known members of the sunfish family, the bluegill, is also found in Melton Hill Reservoir. Identifying characteristics of bluegill are the small mouth, short head, three-spined anal fin, vertical dark bands, a blackish spot on the base of the dorsal fin, and a long, pointed pectoral fin.

Bluegill spawn periodically throughout late spring and summer months. Adult bluegill feed mainly on insects and larvae, but most are caught on worms. Crickets, grubs, and grasshoppers are also good bait for bluegill. Artificial baits range from plastic grubs (Figure 4-D) to flies and popping bugs (Figure 4-F).

Best fishing for bluegill is usually in the late spring and summer. Fishing is usually good near the surface early and late in the day, while the fish generally go deep during midday. Most productive areas for bluegill in Melton Hill are scattered throughout the reservoir (see Bluegill Map). The fish in the upper portion of the reservoir are generally limited to coves and creek embayments. Some of the largest bluegill are caught off the steep rock banks near the dam.

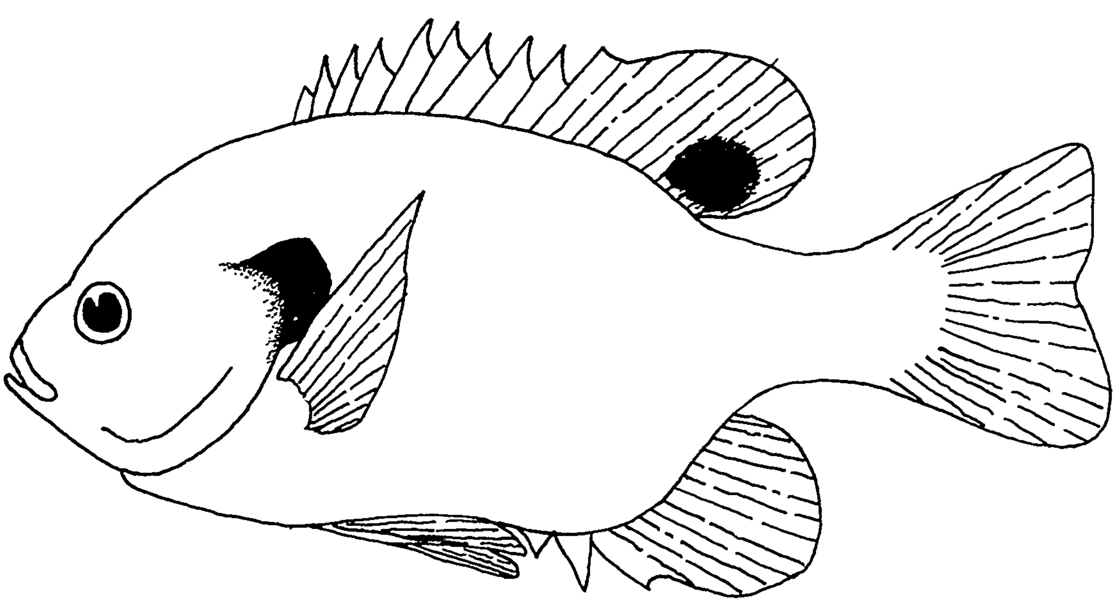
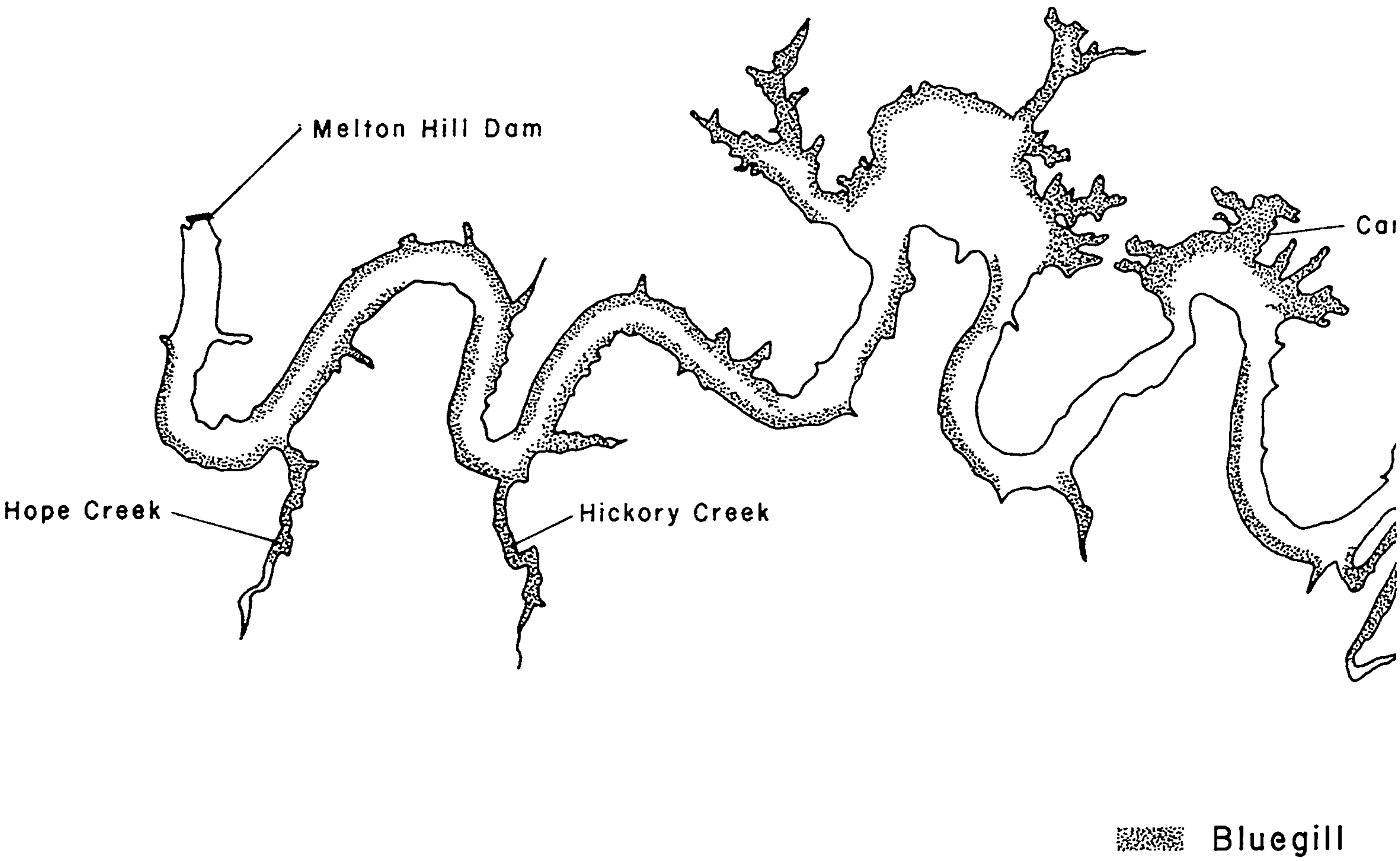
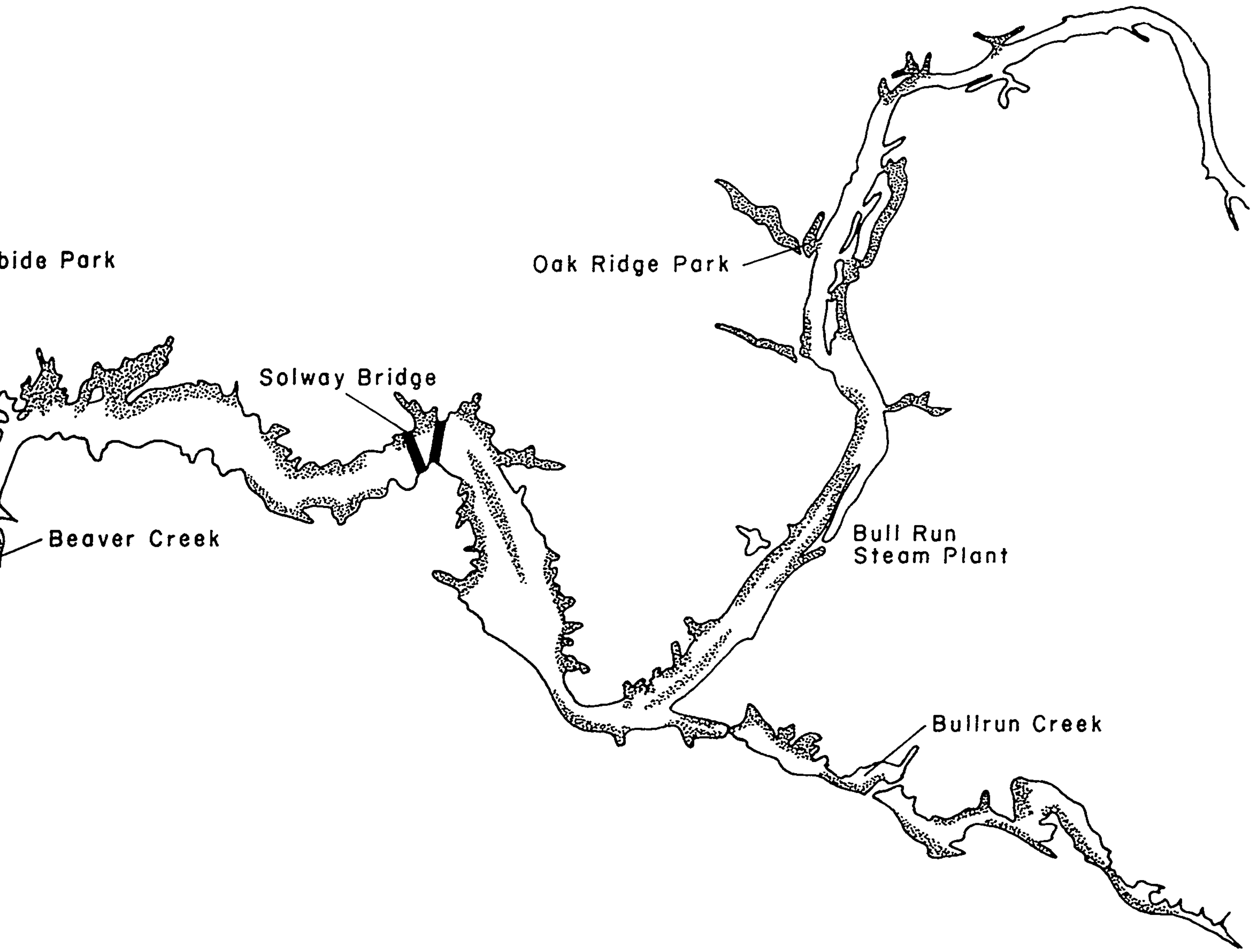


Figure 2. Bluegill



Bluegill


bide Park
Oak Ridge Park
Solway Bridge
Beaver Creek
Bull Run
Steam Plant
Bullrun Creek

Map

Crappie Are Found In Melton Hill Reservoir Embayments

White crappie and black crappie are other members of the sunfish family found in Melton Hill Reservoir. Both have deep bodies and flattened profiles with black spots over a silver background. The black spots on black crappie are arranged randomly over the body while spots on the white crappie are organized in several vertical bar configurations (Figure 3). Another distinguishing character is the number of dorsal spines. There are five or six dorsal spines on white crappie; seven or eight on black crappie.

Crappie normally spawn in mid-April through mid-May in Melton Hill Reservoir. Adult crappie are mainly fish eaters, feeding largely on small shad. Crappie fishermen use small minnows. Artificial baits which include small plastic grubs (Figure 4-D), jigs (Figure 4-H), and small spinners (Figure 4-G) are most effective when used near submerged brush piles, fallen trees, and weed beds.

Most crappie are caught during the spring months when they move into shallow water. During other times of the year, crappie normally retreat to deep water close to structure. Practically all crappie fishing in Melton Hill Reservoir is in embayments and away from the main channel. Bull Run Creek embayment is one particularly good crappie area (see Crappie Map).

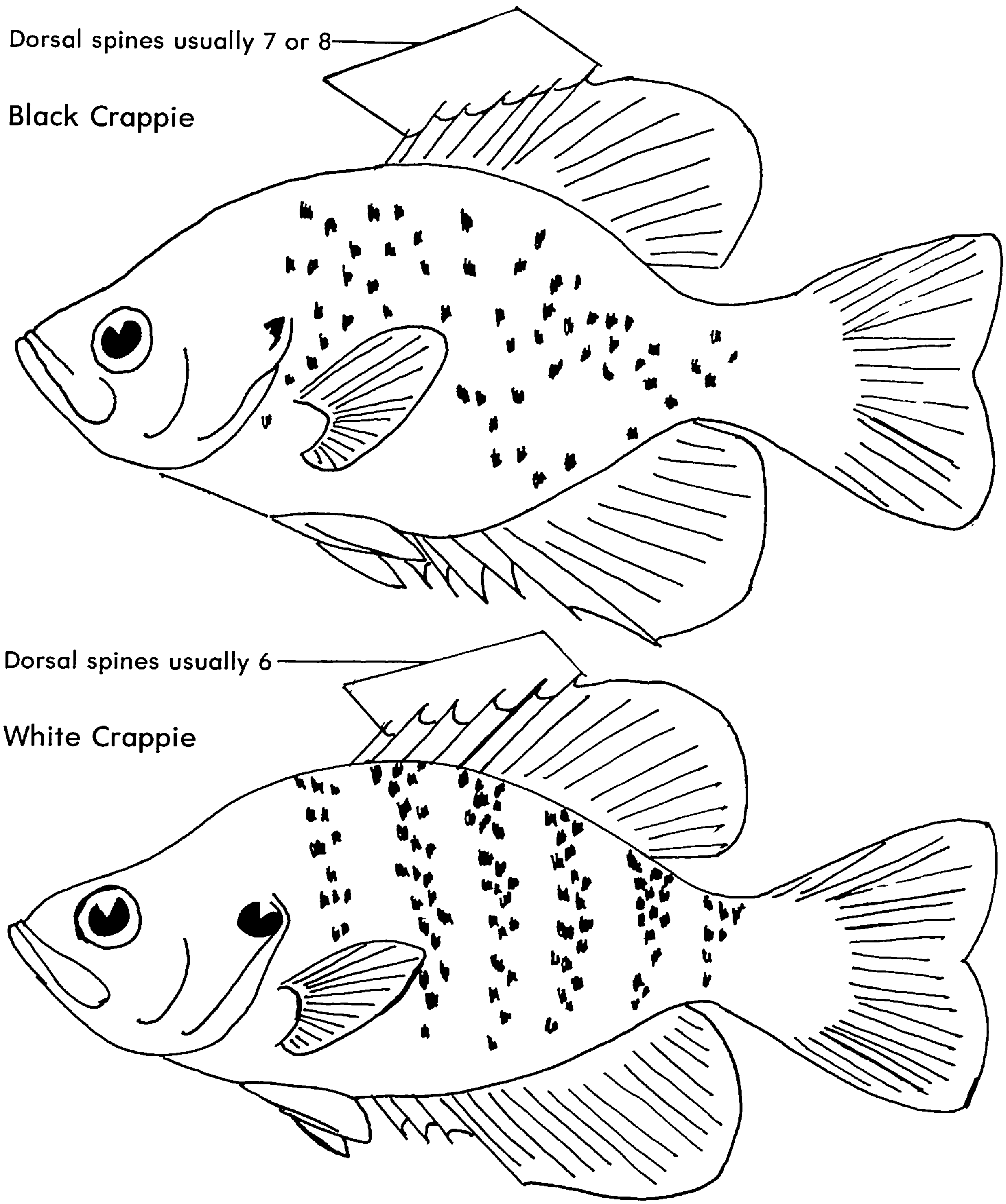
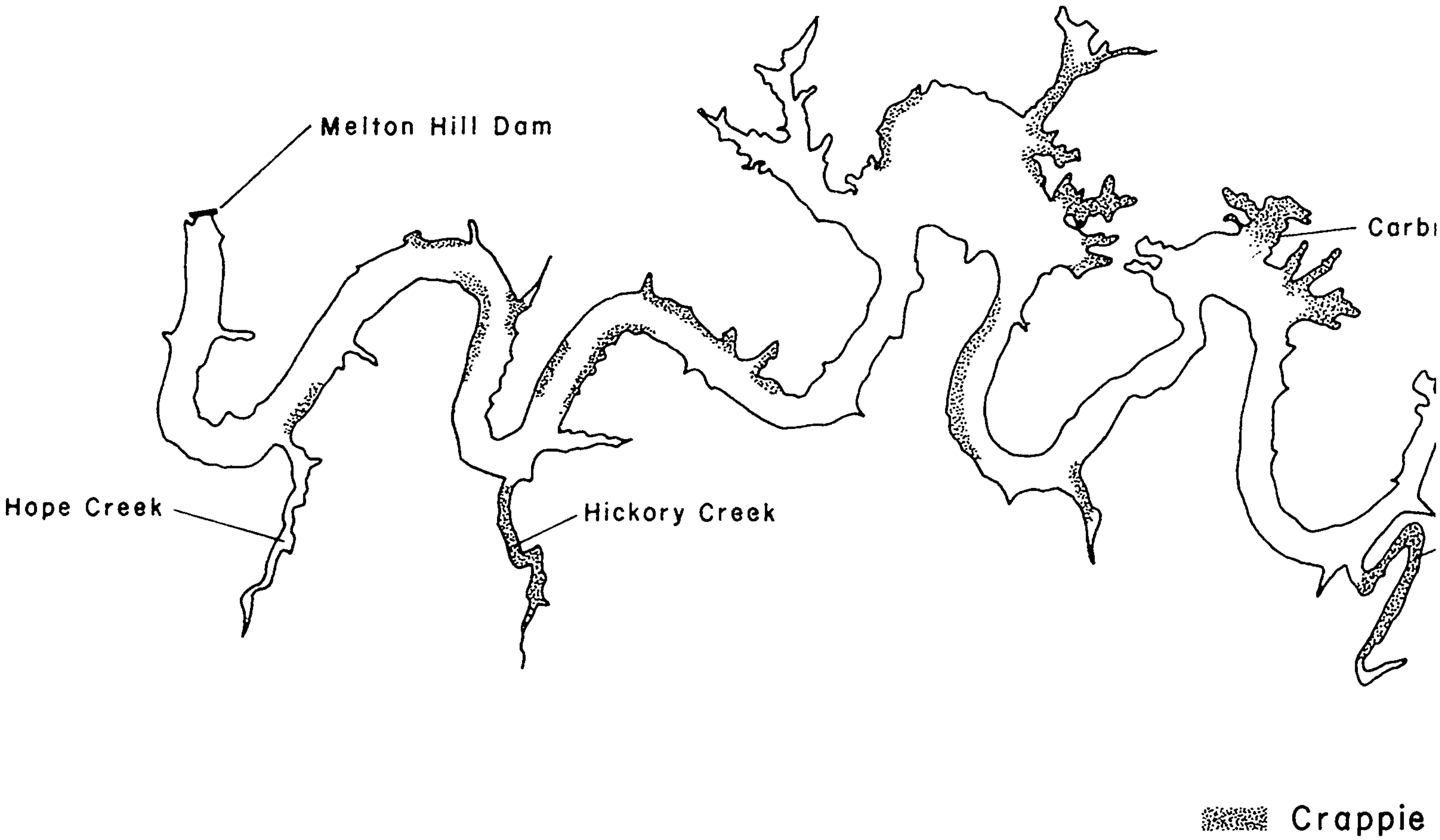


Figure 3. Black and White Crappie



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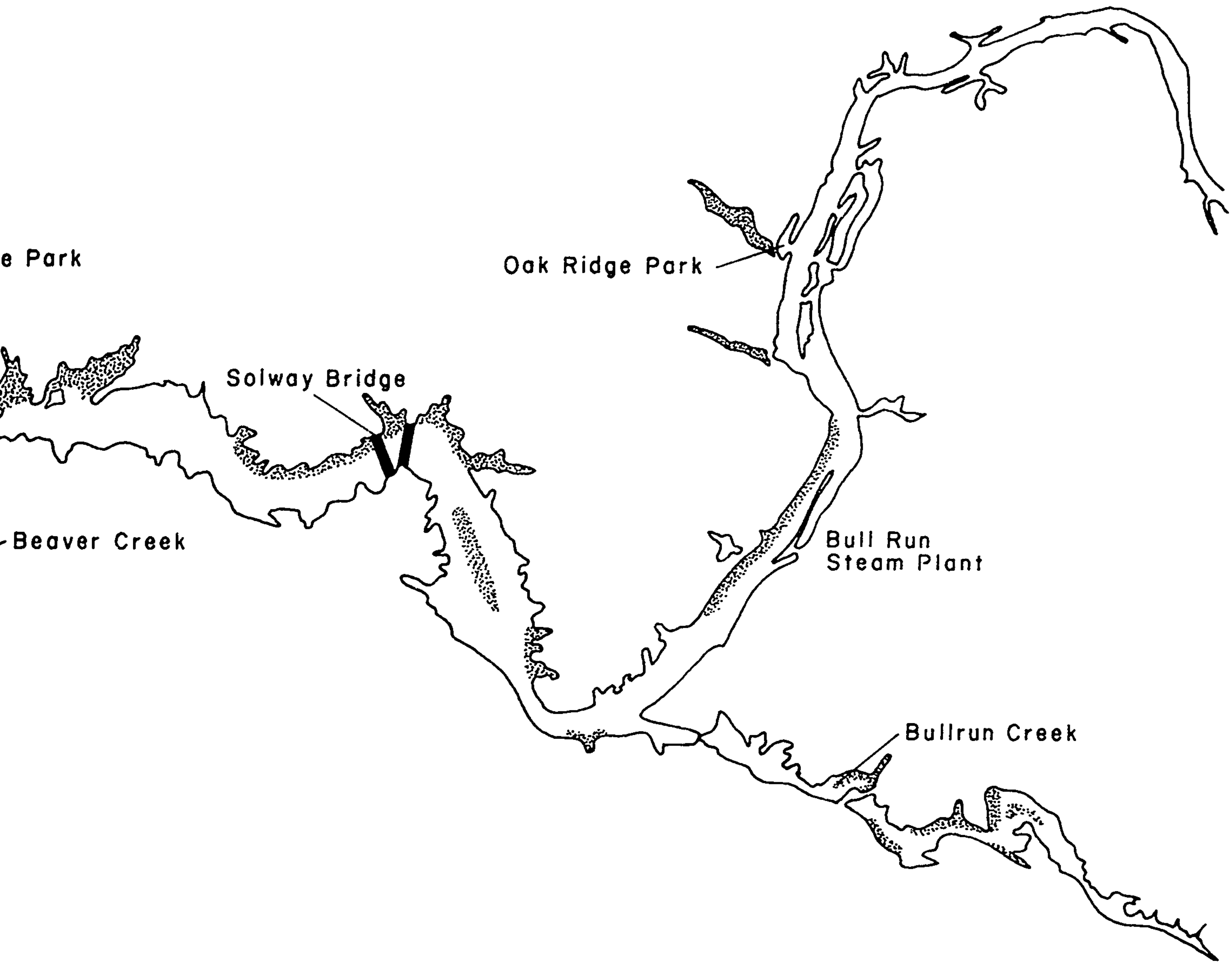


e Park
Oak Ridge Park
Solway Bridge
Beaver Creek
Bull Run
Steam Plant
Bullrun Creek

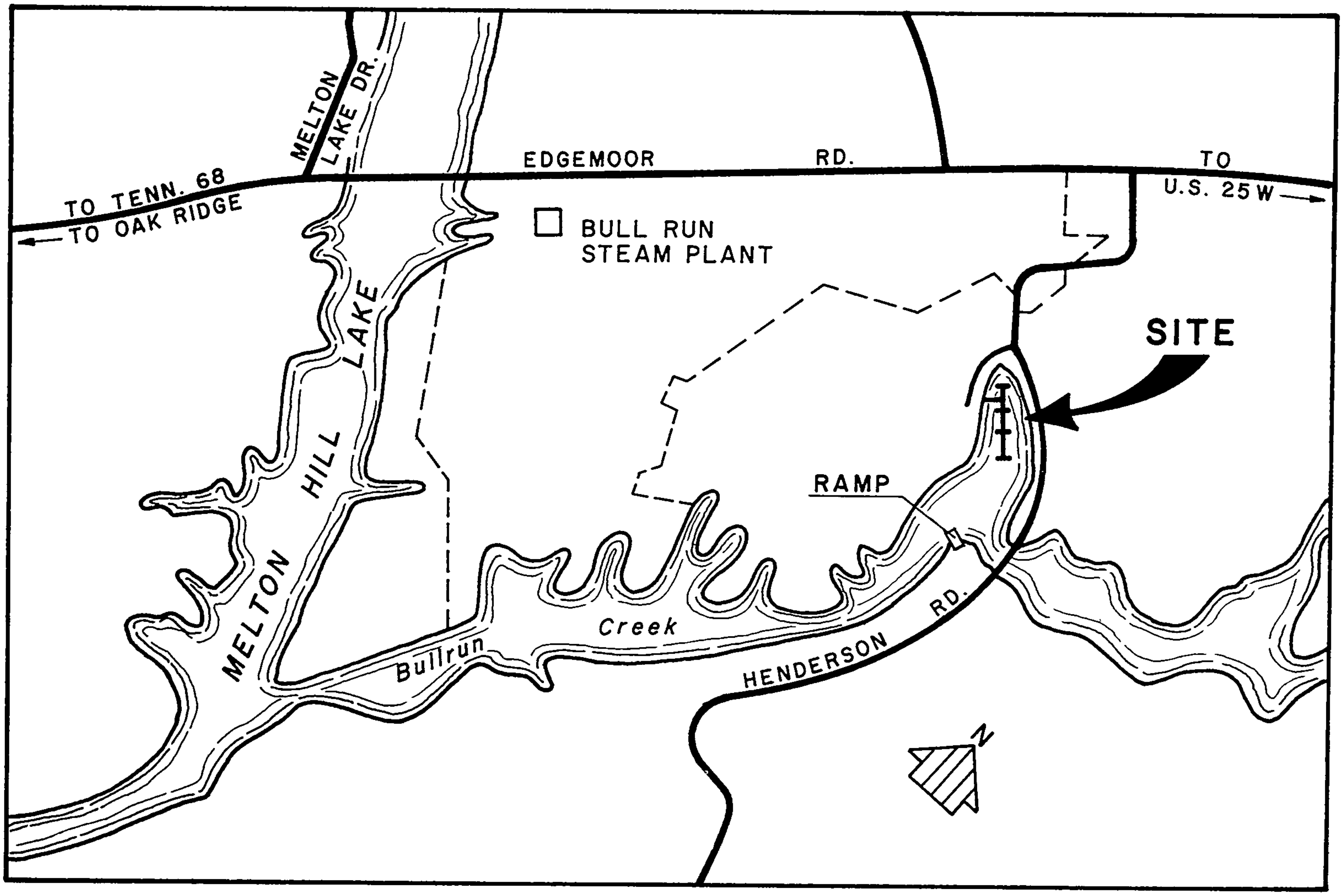
Map

Efforts Are Made To Improve Public Access and Fishing Success

TVA has installed a fishing pier on Melton Hill Reservoir at Bull Run Creek (Bull Run Creek Fishing Pier Location Map). The pier provides easy access to deep water for shoreline fishermen, and fish attractors have also been provided around the pier to concentrate fish so they can be more easily taken by anglers. Major species caught are crappie and bluegill. The pier is lighted, and has a ramp for handicapped fishermen. A launching ramp is nearby and user fees are not charged. The area is maintained by Anderson County.

Another good place to fish on Melton Hill Reservoir is in the Bull Run Steam Plant discharge basin. Small fish tend to congregate in the warm water, particularly during the months when reservoir temperatures are cold. Predator fish in turn gather to prey on the smaller fish.

If large bass and bluegill are what you want to catch, Melton Hill Reservoir is where you should fish. Recent research performed by TVA biologists shows that spawning was successful for nearly all species. Accordingly, the reservoir should offer excellent fishing opportunities in the near future. TVA, in conjunction with Tennessee Wildlife Resources Agency, will continue its attempts to improve fishing success on Melton Hill Reservoir.



Bull Run Creek Fishing Pier Location Map

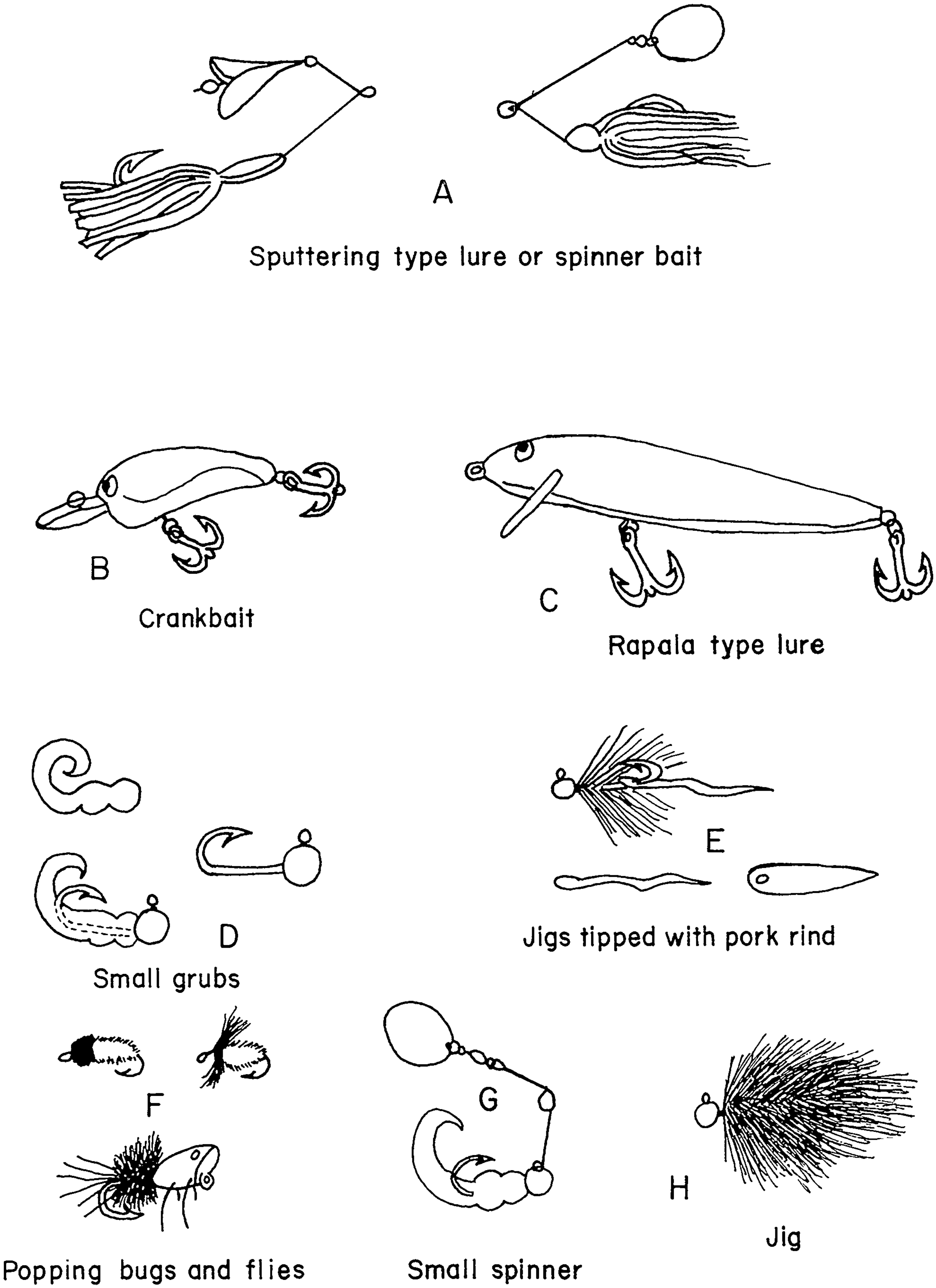


Figure 4. Artificial Lures and Bait

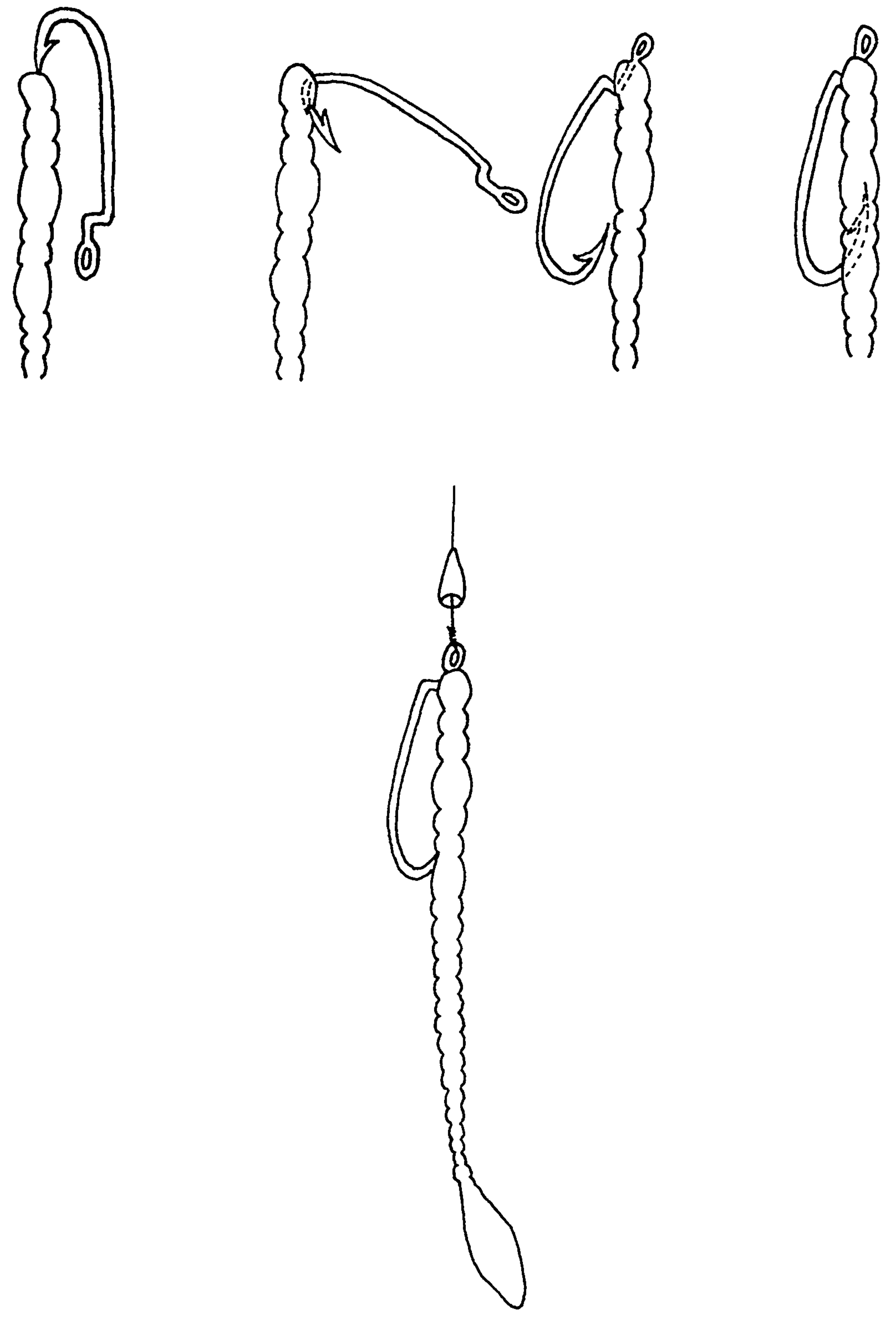


Figure 5. The "Texas Rig"

The diagram shows the " weedless method " used to hook a worm with a slip sinker. It is also commonly called a " Texas rig " and helps to eliminate snagging.

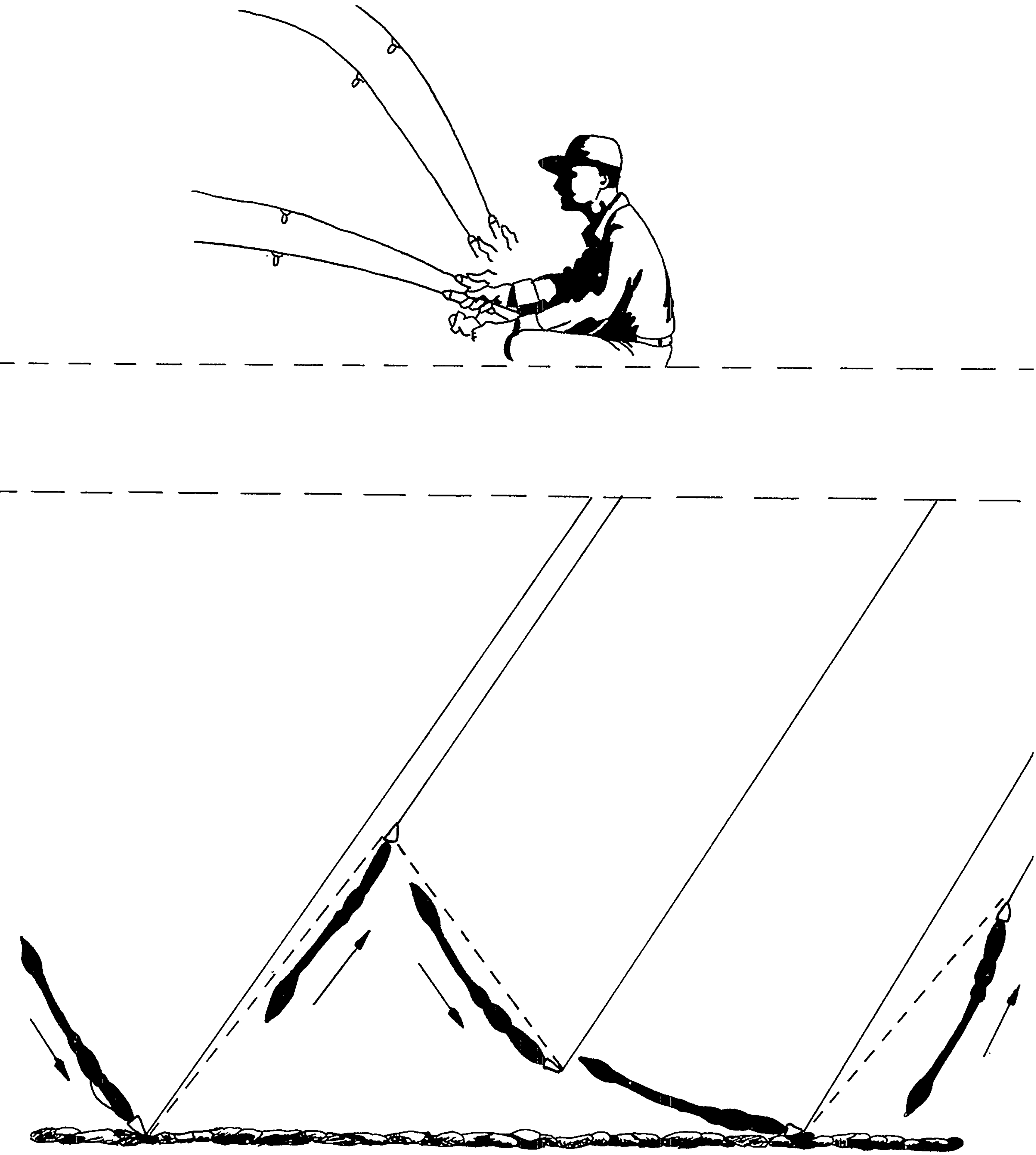


Figure 6. A Pumping Retrieve Method Used With An Artificial Worm

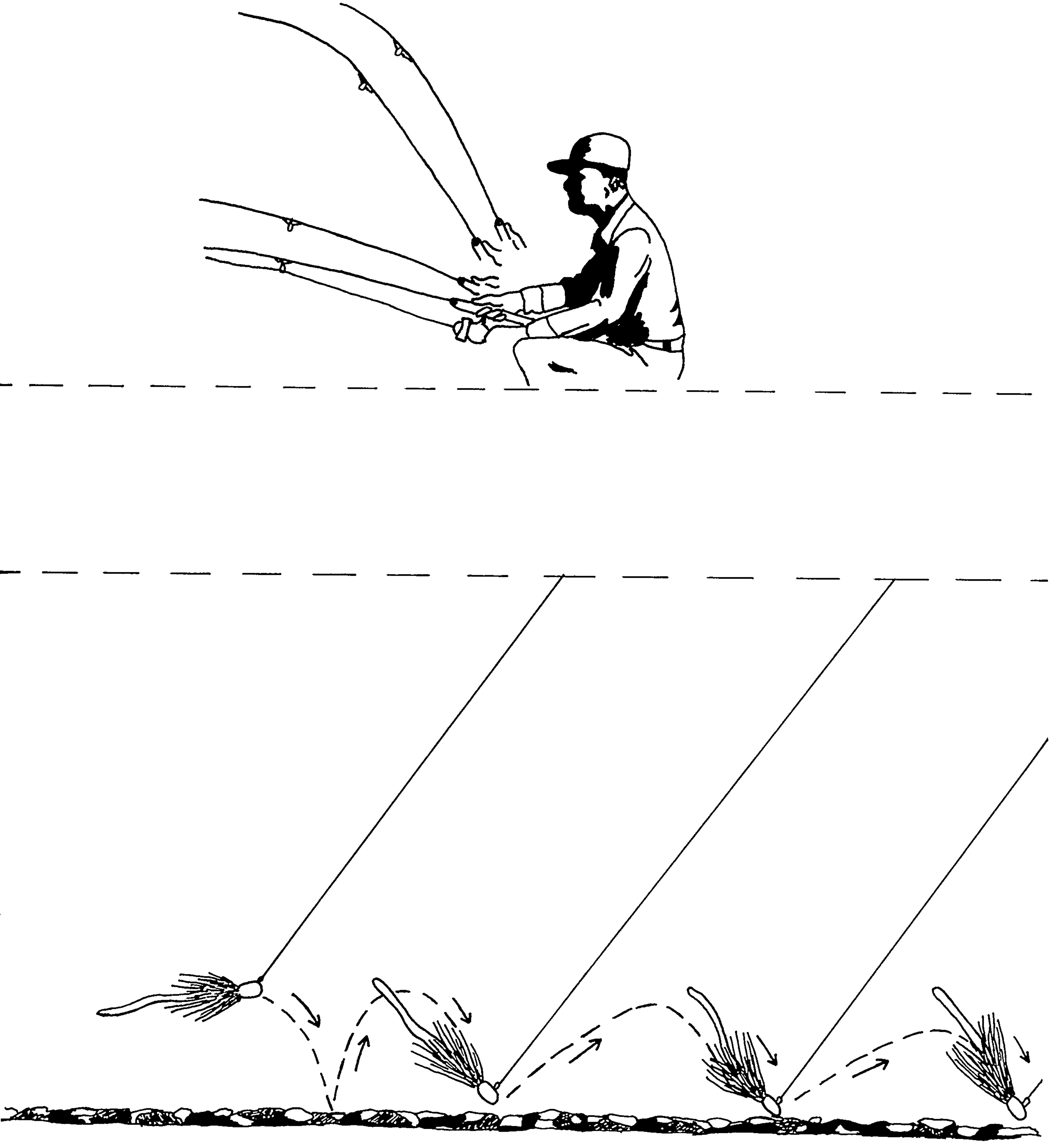
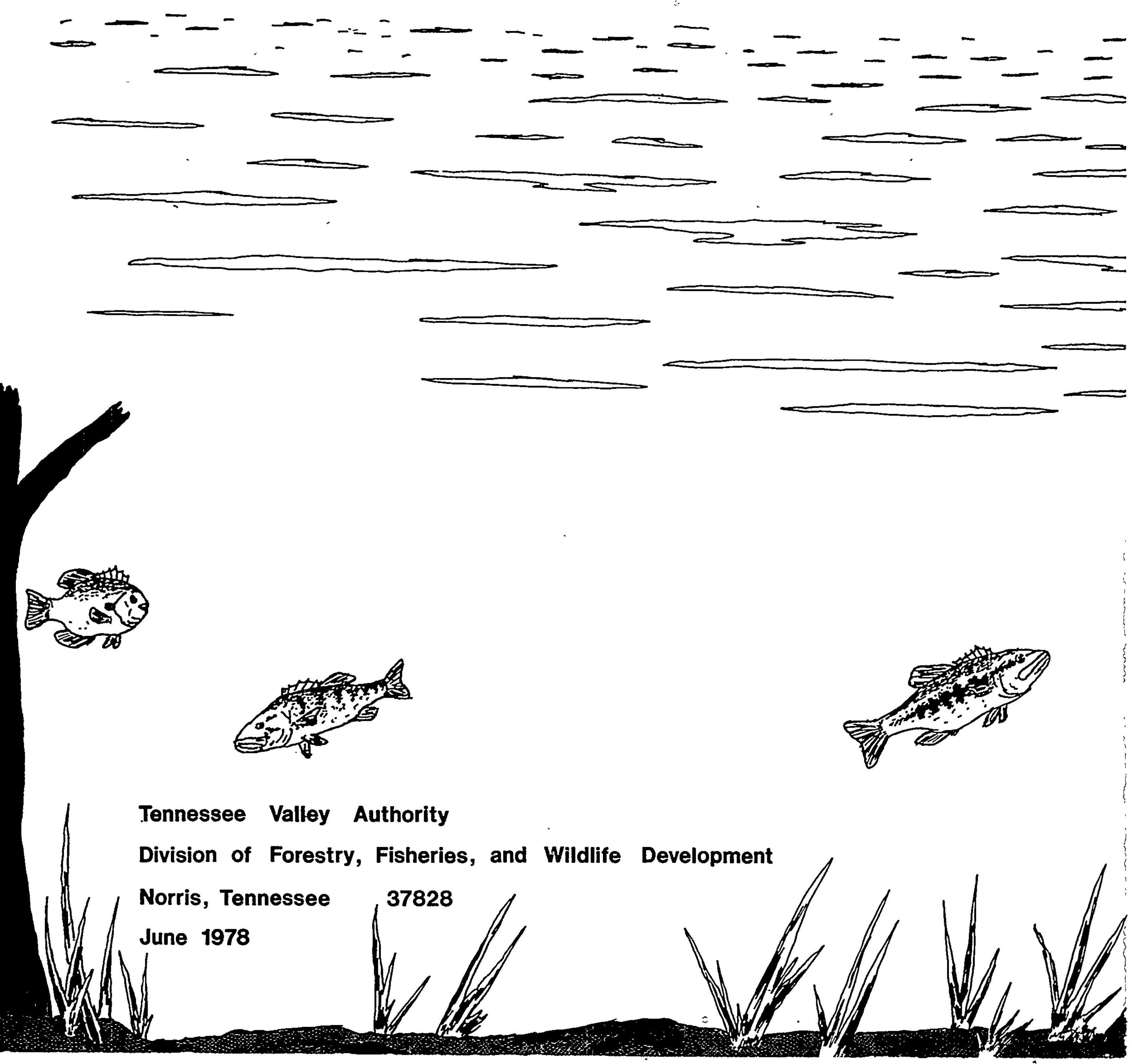
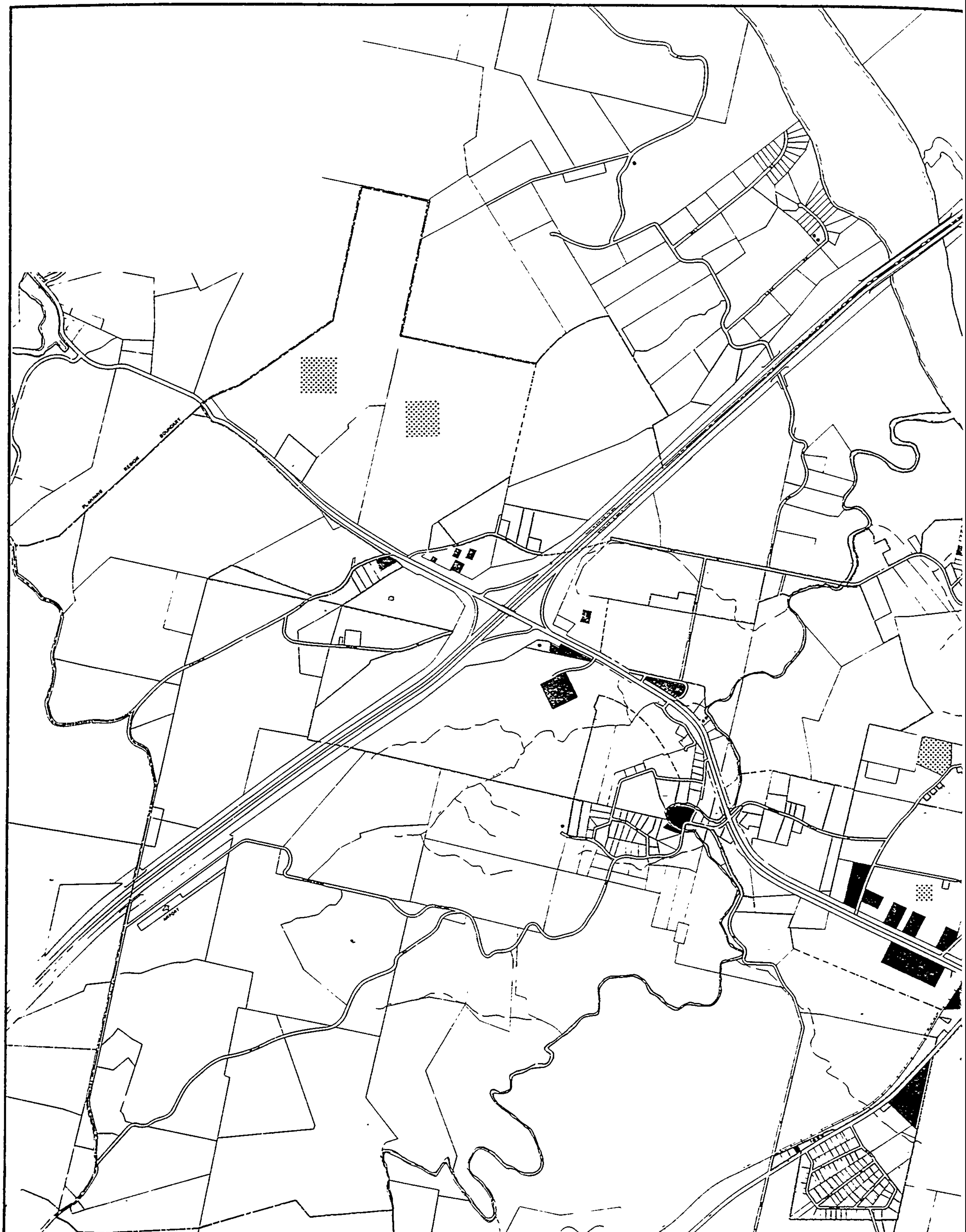


Figure 7. A Pumping Retrieve Method Used With Jigs and Grubs



Tennessee Valley Authority
Division of Forestry, Fisheries, and Wildlife Development
Norris, Tennessee 37828
June 1978


PLANNING REGION BOUNDARY
AIRPORT

Rec'd from Pat Phillips, Loudon [illegible]

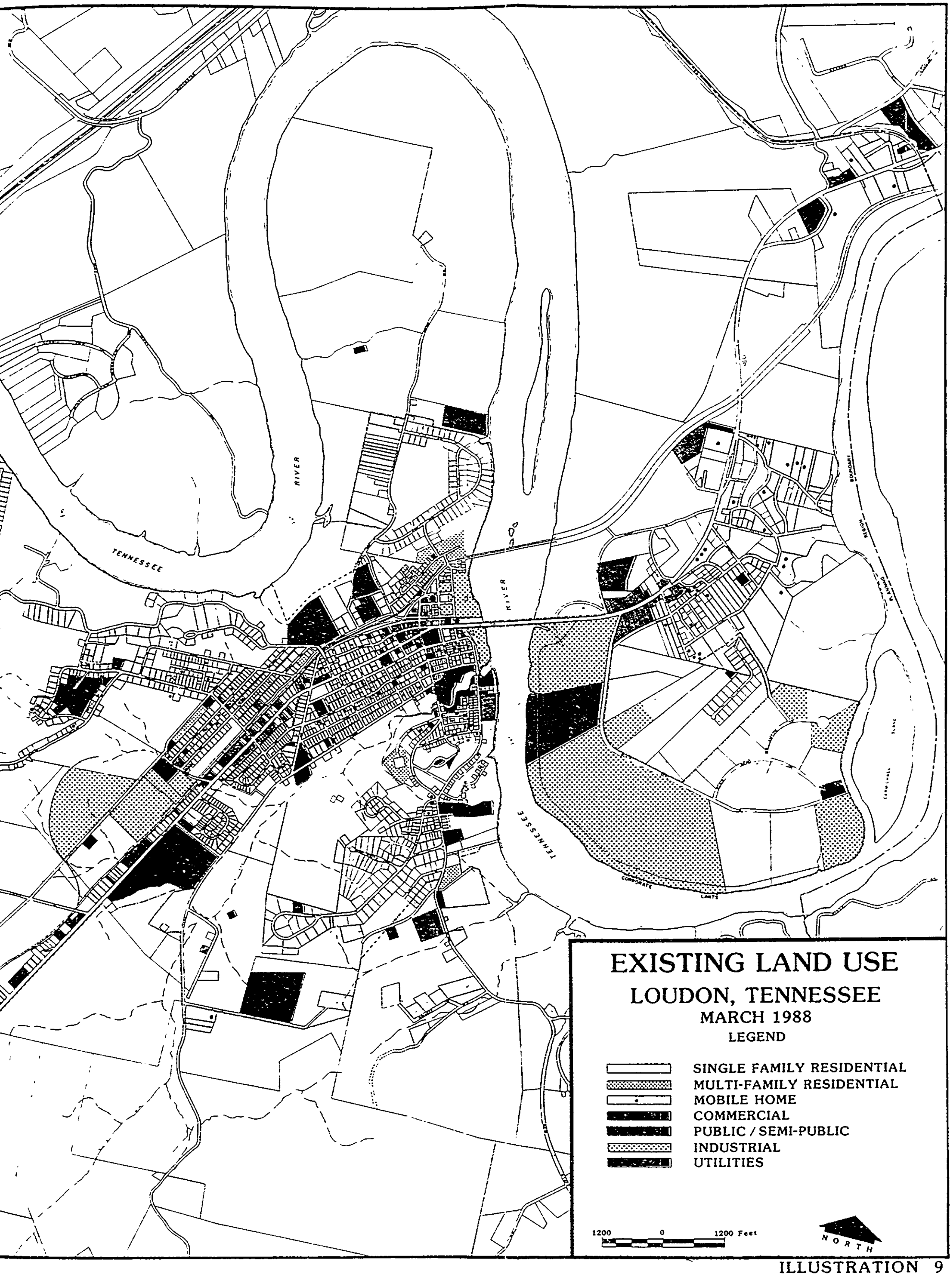


ILLUSTRATION 9


96
units
BATTS BAR LAKE
(TENNESSEE RIVER)
CROOKED OAK
WEST LEE HWY
HUNTSVILLE
HOLLOW
INTERCHANGE
STEVEN
JOHNSON
HAPPY HOLLOW

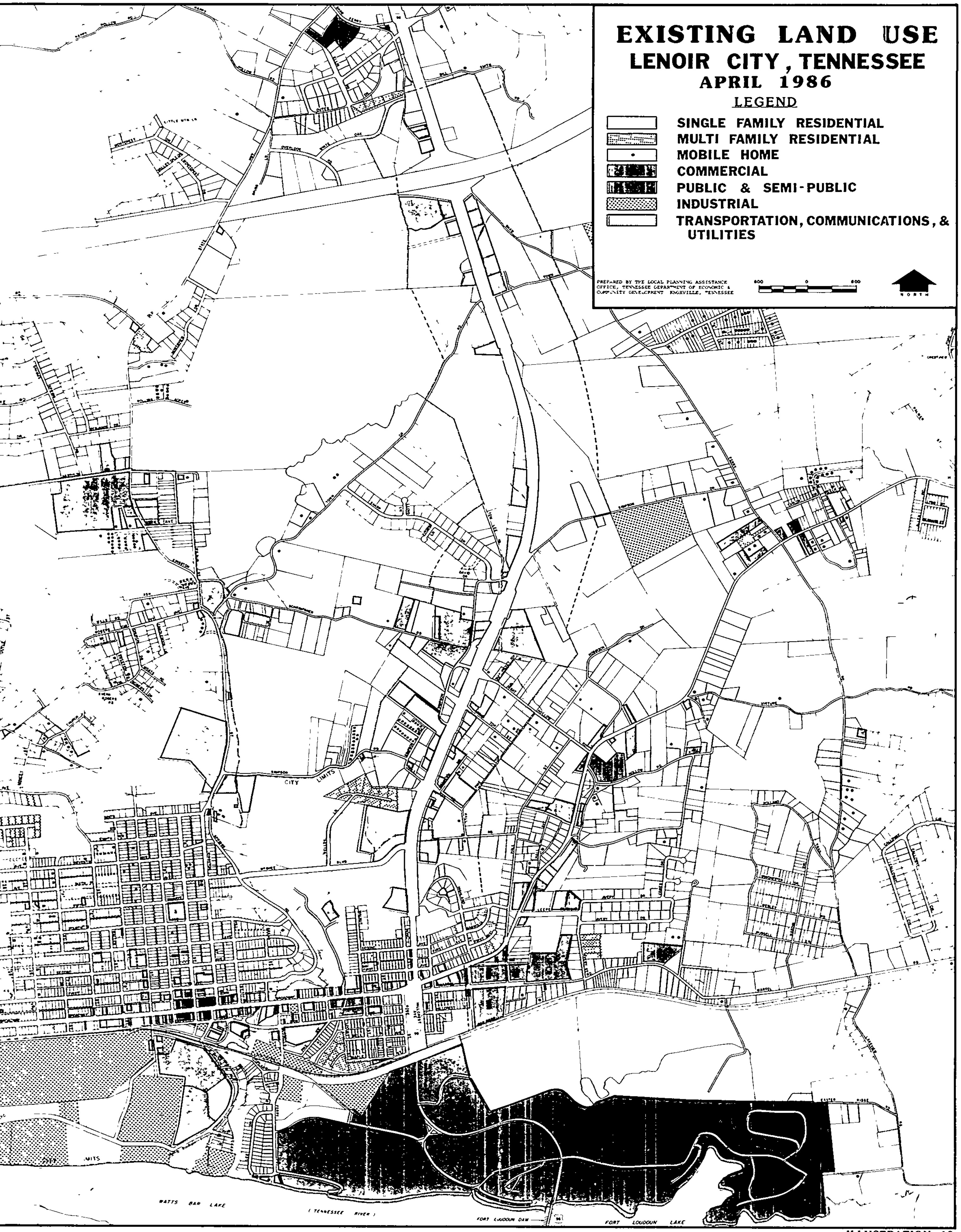


ILLUSTRATION 10

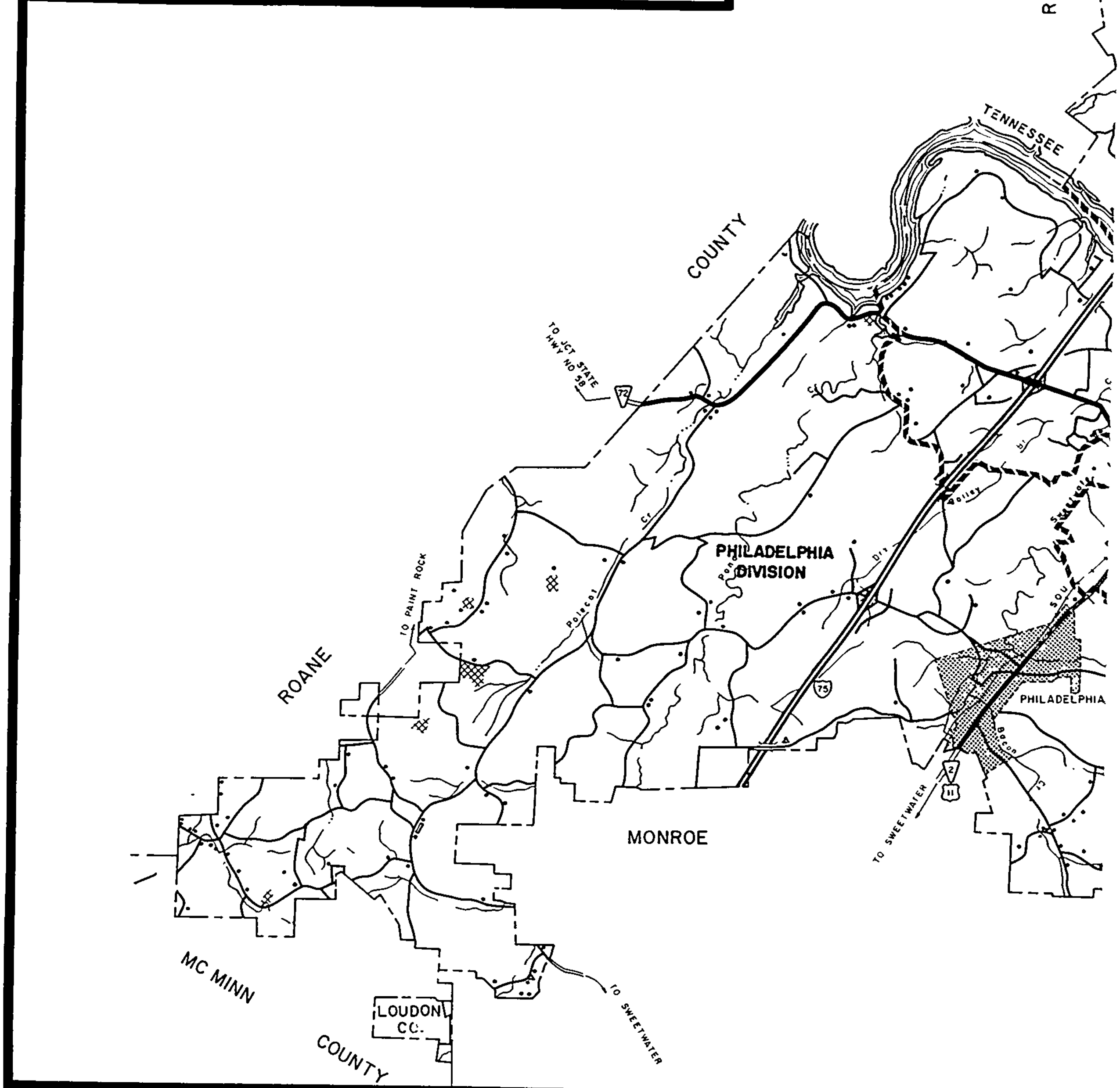
EXISTING LAND USE
LOUDON COUNTY, TENNESSEE
JANUARY , 1975

LEGEND

- RESIDENTIAL
- ● MOBILE HOME
- PUBLIC AND SEMI-PUBLIC
- ● COMMERCIAL
- ▲ INDUSTRIAL
- EXTRACTIVE
- △ TRANSPORTATION, COMMUNICATION, AND UTILITIES
- COUNTY CENSUS DIVISION BOUNDARY

1 0 1 2 3
SCALE IN MILES

BASE MAP PREPARED BY T.S.P.C.
APRIL 1970 REVISED: JANUARY, 1975
THIS IS NOT AN ENGINEERING MAP



Rec'd from Pat Philip - Loudon Co Planner

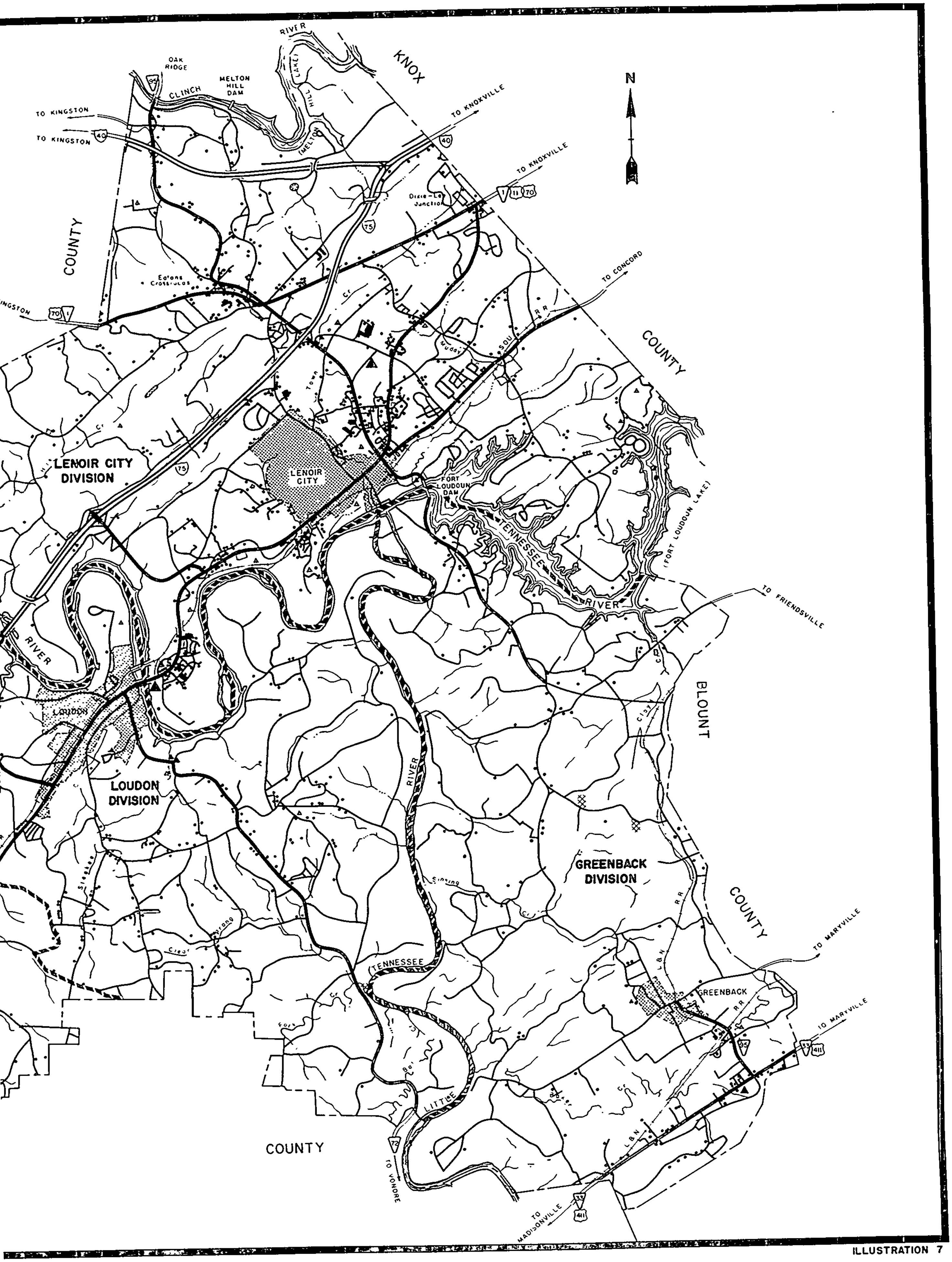


ILLUSTRATION 7

Rec'd 2/93

VISITATION
DATA

	Fort Loudoun	Melton Hill	Norris	Watts Bar
1947	608,000	—	989,200	190,600
1950	531,000	—	2,231,400	442,300
1951	587,200	—	2,700,400	584,000
1952	642,500	—	2,891,200	612,600
1953	687,100	—	3,660,800	661,800
1954	752,900	—	3,156,000	473,700
1955	792,300	—	3,227,100	848,700
1956	861,300	—	3,275,600	926,700
1957	951,000	—	3,521,000	1,082,400
1958	1,120,700	—	3,387,600	1,209,400
1959	1,159,200	—	3,073,800	1,331,300
1960	1,083,900	—	3,217,300	1,325,800
1961	1,103,700	Dam	3,258,800	1,429,700
1962	1,191,900	Constructed	2,926,200	1,666,900
1963	1,181,400	53,000	2,371,500	1,747,700
1964	1,127,900	108,000	2,423,600	1,861,800
1965	1,193,300	175,000	2,492,300	1,966,300
1966	1,569,300	196,500	2,811,900	1,974,300
1967	1,238,900	133,000	2,776,000	1,572,600
1968	1,563,700	150,800	2,842,000	1,523,900
1969	1,618,000	177,600	2,826,100	1,569,800
1970	1,462,500	190,000	2,790,300	1,638,200
1971	1,642,120	189,880	2,665,560	1,679,900
1972	1,849,620	368,380	3,285,900	3,356,700
1973	1,969,120	341,880	3,465,900	3,465,100
1974	1,985,920	402,380	3,181,000	3,150,400
1975	1,510,800			← data missing
1976	1,970,320	522,780	3,284,980	3,146,480
1977	2,064,120	547,480	3,376,300	3,267,240
1978	2,047,000	502,000	3,376,000	3,293,000